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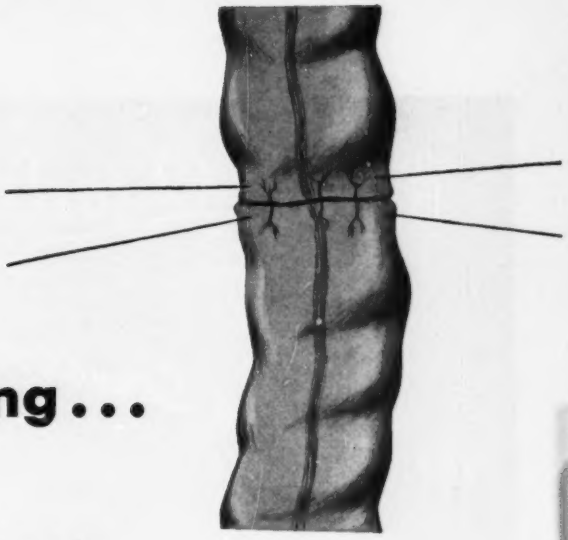

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ANESTHESIA IN INFANTS AND YOUNG CHILDREN FOR MAJOR SURGICAL PROCEDURES

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MONTREAL, CANADA

THE CONSIDERATION of anesthesia for infants and young children implies a knowledge of some of the basic physiologic factors peculiar to this age group. There seems little doubt, for example, that the tiny infant is less sensitive to painful stimuli than the adult. For this reason lesser amounts of narcotizing drugs are required to produce favorable conditions for the surgeon. Likewise special thought must be devoted to the small respiratory tidal exchange in the young child. Ways and means must be found of maintaining good oxygenation during anesthesia while at the same time preventing accumulation of noxious carbon dioxide. Contemplation of the relatively weak respiratory musculature provokes plans of how the resistance in the anesthetic circuit can be reduced and initiates methods of actually assisting the respirations so as to lessen the burden on the child during the operative period.

The delicacy of the metabolic equilibrium in the child is emphasized by the ease with which his fluid balance may be disturbed. Overhydration is just as serious a complication as dehydration. Particularly must one beware of undue administration of sodium chloride, as the infant's kidney is not sufficiently mature to dispose of excesses of the sodium ion easily.[1] Replacement of blood on the operating room table becomes of maximum importance when one recalls that the loss of 1.0 cc. in the infant of 10 pounds (4.5 Kg.) is equivalent to the loss of 18.0 cc. in the adult of 150 pounds (68.0 Kg.).[2] All infants under 2 years of age should have their blood loss replaced at the time of surgical intervention.

PREMEDICATION

Clinical experience has established that a slow stormy induction which is associated with struggling, abundant secretions and bouts of hypoxia often results in an anesthetic course which is laden with difficulties. Much of this distress can be alleviated by proper administration of premedication. By dulling fear and apprehension in the child,

From Children's Memorial Hospital and McGill University.

1. Marriott, H. L.: Water and Salt Depletion, Brit. M. J. **1**:242-250; 285-290 and 328-332, 1947.

2. Brunkow, C. W.: Contrast Between General Surgery of Infants and Children and That of Adults, Northwest Med. **35**:259-263, 1936.

lowering his high metabolic rate, lessening the salivary secretions and obtunding the vagal influences, a smooth induction can be a "fait accompli." In infants under 6 months of age the injection of scopolamine, 1/600 grain (0.1 mg.), produces good drying and sedative reactions without central depression of the respiratory center. In older age groups morphine is added to the scopolamine according to the dosages established by Leigh and Belton (table 1).[3] This combination does not produce depression of the respiration and bears out the contention that scopolamine counteracts the respiratory depression created by morphine.[4]

AGENTS AND TECHNICS

In any discussion on anesthesia for children, it must be understood that the technic used to produce narcosis is of greater importance than

TABLE 1.—*Premedication*

Age	Morphine, Grain	with	Scopolamine, Grain	or	Atropine, Grain
Up to 2 mo.	.....		1/600		1/400
2-3 mo.	.....		1/600		1/400
3-4 mo.	.....		1/600		1/400
4-7 mo.	1/144		1/600		1/400
7-11 mo.	1/120		1/600		1/400
11-18 mo.	1/108		1/600		1/400
18 mo.-2 yr.	1/72		1/450		1/300
2-3 yr.	1/60		1/450		1/300
3-5 yr.	1/48		1/450		1/300
5-8 yr.	1/36		1/300		1/200
8-10 yr.	1/24		1/300		1/200
10-12 yr.	1/18		1/200		1/100
12-14 yr.	1/12		1/150		1/75

the agent employed. Any anesthetic drug which has been used with safety in adults can be employed in children. However, the anesthetist must be fully cognizant of the dangers inherent in any narcotic, because in children the margin of safety between satisfactory anesthesia and respiratory and cardiac arrest is much narrower than in the adult. Ethyl ether is still considered the safest agent known. Probably the reason for this is that satisfactory narcosis and relaxation can be obtained in a plane of anesthesia which not only produces little respiratory depression but also is remote from that which produces respiratory arrest. Moreover, if respiratory arrest should occur, there is still time

3. Leigh, M. D., and Belton, M. K.: Pediatric Anesthesia, New York, The Macmillan Company, 1948.

4. Waters, R. M.; Bennett, J. H., and Leigh, M. D.: Effects upon Human Subjects of Morphine and Scopolamine Alone and Combined, J. Pharmacol. & Exper. Therap. **63**:38-39, 1938.

for the alert anesthetist to remedy affairs before cardiac rhythm is disturbed. In a recent series of 1,007 anesthesias for major surgical procedures in children, of which 378 were for infants under 2 years of age (table 2), it is interesting to note that ether was employed in a large majority (table 3). The frequency with which nitrous oxide was utilized should also be mentioned. This agent, which has low narcotic potency but high analgesic value and which alters metabolism little, was never used with less than 25 per cent oxygen. By using it as a vehicle for the volatilization of ether, the amount of the latter agent can be reduced

TABLE 2.—*Types of Operations*

Pyloromyotomies	44
Herniorrhaphies (under 2)	94
Operations for congenital defects (infants)	68
Operations for harelips, cleft palates	120
Plastic operations (others)	115
Intra-abdominal procedures	293
Intrathoracic procedures	50
Orthopedic operations	180
Miscellaneous	43
	1,007

TABLE 3.—*Agents Employed*

Vinyl ether, ether, nitrous oxide, oxygen	497
Ether, nitrous oxide, oxygen	122
Vinyl ether, ether	56
Ether	4
Barbiturate, nitrous oxide, oxygen	59
Barbiturate, nitrous oxide, oxygen, curare	65
Cyclopropane	72
Nitrous oxide, oxygen	13
Spinal and regional agents	116
Others (inhalation)	3
	1,007

considerably. In the use of smaller amounts of ether, the tendency to acidosis and dehydration, which are associated with its employment, becomes of lesser significance. In other words, the metabolism of the child is upset to a smaller degree, and he remains closer to the physiologic normal.

Any technic which is devised for anesthetizing small children should have the following aims in view: abolition of dead space; reduction of resistance to a minimum; prevention of accumulation of carbon dioxide, and maintenance of as even and light a plane of anesthesia as is compatible with the surgical procedure. The more closely these requirements can be fulfilled, the less will the child suffer during his period of narcosis. In the cases under consideration several technics were

employed (table 4). Perhaps the most surprising fact is the frequency with which the children were intubated, but the advantages of the endotracheal tube were felt to be worth the possible hazards inherent in its use. Employment of a tube reduced the dead space considerably, thereby lessening the danger of carbon dioxide accumulation. It provided a mechanically patent airway which obviated the possibility of increased resistance due to obstruction in the upper respiratory tract. It enabled the anesthetist to maintain the patient in a lighter, more even plane of anesthesia than would have been possible otherwise. The disadvantages of intubation, namely, trauma and inflammatory reaction in the larynx and trachea, did not present a serious problem. For the most part they could be avoided by intubating in deeper planes of anesthesia where reflexes were not active and by the liberal coating of the endotracheal tube with an anesthetic ointment. The skill and gentleness of the anesthetist were always an asset in achieving atraumatic intubation.

TABLE 4.—*Technics*

Open drop	65
Partial rebreathing	78
Carbon dioxide absorption	72
Intravenous and partial rebreathing	84
Nonrebreathing	592
Spinal and regional	116
	1,007
Endotracheal	715

Although open drop ether was not employed to a large extent for major procedures, its value should not be disregarded. In actual fact the ether mask was commonly employed for induction, with vinyl ether (vinethene®) preceding the ether to produce rapid unconsciousness. When the ether mask is used, it is of extreme value to insufflate oxygen at the rate of 2 to 3 liters per minute under the mask. In this way hypoxia is avoided, the tendency to laryngospasm is reduced and accumulation of carbon dioxide under the mask is a virtual impossibility.

A partial rebreathing, or semiopen technic, was sometimes the method of choice. Here the face mask and reservoir bag are potential sources of dead space and carbon dioxide accumulation. To overcome these hazards, high flows of gases, which at least equal the minute volume of the patient, must be used.

The partial rebreathing technic may be combined satisfactorily with intravenous anesthesia. In such instances one must be on the watch for central respiratory depression resulting from overdosage of barbiturates. This depression should be overcome by rhythmic manual supplementation of the patient's respirations. Otherwise, dangerous

hypoxia will occur and the carbon dioxide content of the blood and tissues will rise insiduously, with a gradual increase in the pulse rate and blood pressure.

In older children the carbon dioxide absorption technic is satisfactory, but in those under 6 years of age undergoing lengthy surgical procedures the resistance inherent in such a circuit and the carbon dioxide which may accumulate under the mask may be such as to produce in a patient a degree of fatigue and disturbance of metabolism which he should not be asked to bear.

It has been found over a trial and error period, during which different techincs were evaluated, that one which employs a nonrebreathing

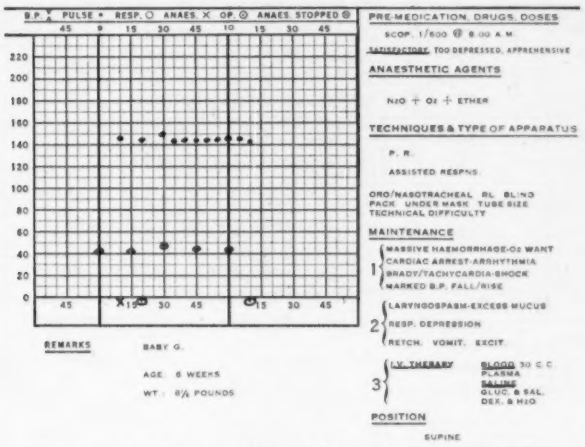

Fig. 1.--Anesthesia record for an infant undergoing pylorotomy.

valve close to an endotracheal tube is most satisfactory.[5] With this method the amount of dead space is reduced to a minimum of about 15 cc., mechanical control is maintained over the patient's airway, there is a minimal resistance in the efficient rubber valves and means are at hand manually to aid the child's inspirations or to provide artificial respiration if necessary. The agents commonly employed with this technic are nitrous oxide and oxygen, with ether added as required. With such a system the patient is at all times kept close to the physiologic normal, the anesthesia can be deepened rapidly according to the requirements of the surgeon and the anesthetist is master of the child's respiratory mechanisms.

5. Stephen, C. R., and Slater, H. M.: A Non-Resisting, Non-Rebreathing Valve, Anesthesiology **9**:550-552, 1948.

ANESTHESIA FOR PYLOROMYOTOMIES

These procedures are usually performed in infants under 2 months of age. On the infant's admission manifest dehydration is present, and the risk of the operation is lessened if surgical intervention is postponed until some measure of hydration is restored. Anesthesia need not provide profound relaxation if an incision parallel to the costal margin is made, because the liver acts as a splint to prevent extrusion of abdominal contents. For this reason patients may be anesthetized satisfactorily by the employment of a partial rebreathing technic with a small bag and mask. Nitrous oxide and oxygen, in a 75 : 25 ratio, with traces of ether added are the agents utilized. Respirations are aided throughout by

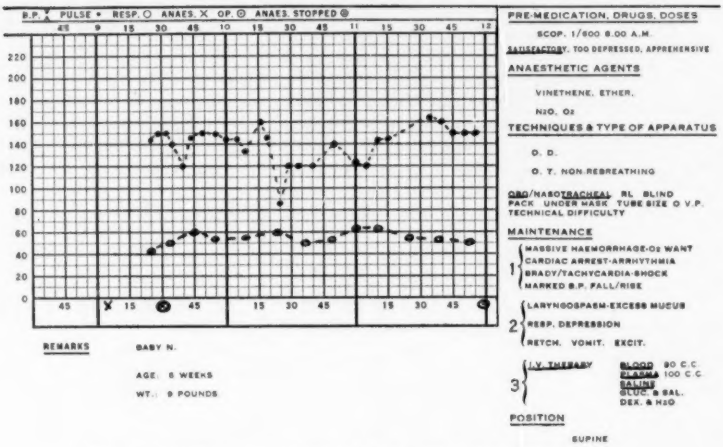

Fig. 2.—Anesthesia record for an infant undergoing cholecystectomy.

manual pressure on the reservoir bag, and the excess gases are allowed to escape between the mask and the face. In this way fatigue is lessened in the patient, and there is less danger of carbon dioxide accumulating. Positive pressures up to 15 cm. of water may be applied during inspiration without danger. The infants are maintained in light planes of anesthesia and are awake and crying at the conclusion of the operation. A typical record is shown of an infant 6 weeks old (fig. 1). Anesthesia for herniorrhaphies in patients under 2 months of age can be handled satisfactorily in a similar way.

ANESTHESIA FOR CONGENITAL DEFECTS

In this group are included such conditions as tracheoesophageal fistula, congenital malformations of the alimentary tract and gallbladder,

diaphragmatic hernia and congenital cystic disease of the lung. To achieve satisfactory operating conditions the infants are best intubated and maintained on nitrous oxide, oxygen and small amounts of ether with the nonbreathing valve. In the newborn, breathholding may be so pronounced during induction with the open drop ether mask that it is necessary to intubate with the patient awake. No difficulty or hazard has been experienced in this maneuver if the lungs are first filled with oxygen for two to three minutes. During a lengthy procedure oxygenation is often enhanced and fatigue reduced in the infant by manually aiding the respirations. No cases of laryngeal edema have followed the use of endotracheal tubes in such infants. A chart is shown (fig. 2)

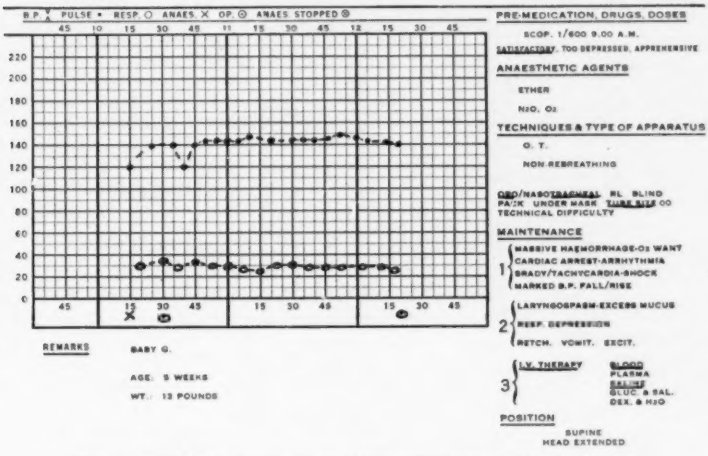

Fig. 3.—Anesthesia record for an infant undergoing repair of a harelip.

of a 6 week old infant weighing 9 pounds (4.1 Kg.) who underwent a two and a half hour procedure with the aforementioned technic for a congenital defect of the gallbladder. Cyclopropane may be used successfully as an adjunct to nitrous oxide instead of ether.

ANESTHESIA FOR HARELIPS AND CLEFT PALATES

The plastic surgeon prefers to repair harelips at about 6 weeks of age and cleft palates at 14 to 16 months of age. Only by insertion of an endotracheal tube can the anesthetist assume complete control over the airway, provide adequate oxygenation at all times and prevent aspiration of blood, with its dangerous sequelae. Anesthesia may be conducted with Ayre's T piece or with a nonrebreathing valve close to the

endotracheal tube. The latter technic presents the advantage of a reservoir bag by means of which artificial respiration may be instituted at a moment's notice. Blood loss is a major consideration in these cases, and convalescence is speeded if the anesthetist is careful to replace on the table that which is lost. Illustrated is a typical anesthetic record of a harelip repair in an infant 5 weeks old (fig. 3).

ANESTHESIA FOR INTRA-ABDOMINAL PROCEDURES

As a rule the young child who comes to the operating room with an acute condition within the abdomen has an associated major metabolic upset. The food and fluid intake has been reduced, vomiting has added

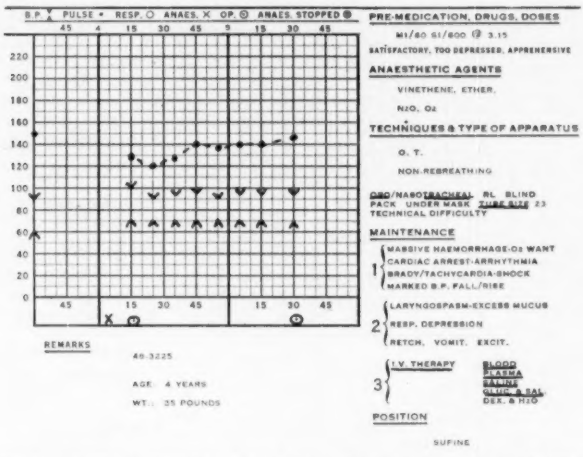

Fig. 4.—Anesthesia record for a boy undergoing laparotomy for acute intestinal obstruction.

to his dehydration and fever has increased his already high metabolic rate. As a result, his glycogen reserves are depleted and he is burning his fat, with the production of acetonuria. He is a sick child. In the anesthetic management large quantities of ether should be avoided as this agent in sufficient concentration will add to the dehydration and metabolic acidosis already present. A technic which guarantees complete elimination of carbon dioxide is desirable, as one does not wish to add a gaseous acidosis to the metabolic acidosis already present. An endotracheal nonrebreathing technic using nitrous oxide and oxygen in a 75:25 ratio, with small quantities of ether or curare added, fulfils most of these requisites. Likewise a combination of thiopental sodium, nitrous oxide and oxygen and curare disturbs the metabolism little. In

the child over 4 years of age spinal analgesia may at times be the method of choice. Injection of a hypobaric dilute tetracaine hydrochloride solution is safe and provides adequate operating conditions. Figure 4 shows the anesthetic record of a dehydrated, toxic, 4 year old boy with acute intestinal obstruction.

ANESTHESIA FOR INTRATHORACIC PROCEDURES

In recent years operations for correction of congenital cardiac defects and for lobectomy and pneumonectomy have become commonplace in children. Anesthesia for such major procedures requires careful attention to detail. There is little disturbance of the metabolism of

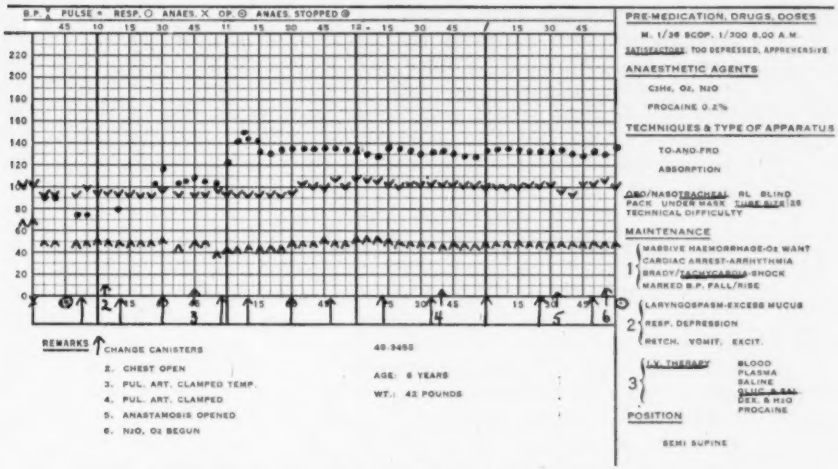

Fig. 5.—Anesthesia record for a girl undergoing pulmonary-subclavian anastomosis for a tetralogy of Fallot.

the patient, and he may be kept well oxygenated if cyclopropane is used in a to and fro absorber circuit. Small quantites of ether may be added if the anesthetist so desires. Assisted or compensated respirations are of value as they reduce the respiratory efforts of the patient, make for better oxygenation and elimination of carbon dioxide and reduce diaphragmatic flap and the tendency to mediastinal shift. Absorption canisters should be of such a size that they equal the tidal volume of the patient. They should be changed and cooled in ice every ten to fifteen minutes so as to keep down the temperature of the inspired gases and to avoid any carbon dioxide accumulation. Intravenous administration of 0.2 per cent procaine hydrochloride may be of value in

reducing the incidence of cardiac arrhythmias and potent vagal mediastinal reflexes during operations. It probably also is useful to spray the mediastinum and pericardial sac with 1 per cent procaine hydrochloride. It is beneficial in these lengthy procedures to change to a partial rebreathing technic with nitrous oxide and oxygen during the closure. In this way one tends to lessen the possibility of "cyclopropane shock" in the immediate postoperative period. Illustrated is an anesthetic record of a pulmonary-subclavian anastomosis for a tetralogy of Fallot in a 6 year old girl weighing 42 pounds (19.1 Kg.) (fig. 5).

SUMMARY

An attempt has been made to show the physiologic advantages of certain anesthetic technics in infants and small children. Because of the relatively narrow margin of safety imposed on the anesthetist, he must at all times be careful in detail, meticulous in observation, gentle in maneuver and skilful in technic.

INCIDENCE OF HIATUS HERNIA IN PATIENTS WITHOUT SYMPTOMS

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AND
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IN THE evaluation of the clinical significance of the esophageal hiatus hernia, the question of how frequently this lesion exists without symptoms assumes considerable importance. In view of the increasing incidence in the diagnosis of hiatus hernia, largely due to more frequent routine use of various positional maneuvers of the patient during the roentgenologic examination of the upper gastrointestinal tract, the problem of asymptomatic hiatus hernia is of greater interest. For instance, in a recent study [1] hiatus hernia was the second most frequent diagnosis made for 3,448 patients undergoing roentgenologic study of the upper gastrointestinal tract after a barium meal. Duodenal ulcer was diagnosed in 705 patients while hiatus hernia was present in 308 patients.

There is great variance of opinion in the literature as to the importance and incidence of asymptomatic patients with hiatus hernia. In most reports the authors present various features of the clinical picture so that the majority of studies are concerned with patients assumed to be having symptoms from their hiatus hernias. However, there are many statements to the effect that asymptomatic hiatus hernia occurs with varying degrees of frequency, without attempts to present objective data. For instance, Shanks [2] estimated that 20 per cent of cases are asymptomatic, especially in the early stages. Wilkinson,[3] however, claimed after a case study that in only 4 of his 70 cases were there no

From the Radiology Department, Walter Reed General Hospital and the Department of Medicine, Georgetown University School of Medicine.

Read before the Section on Radiology at the Ninety-Eighth Annual Session of the American Medical Association, Atlantic City, N. J., June 8, 1949.

1. Brick, I. B.: Clinical Significance of Hiatus Hernia, Mississippi Valley M. J. **71**:2, 1949.

2. Shanks, S. C.: Hiatus Hernia, Brit. J. Radiol. **21**:55, 1948.

3. Wilkinson, S. A.: Diaphragmatic Hernia, New England J. Med. **210**:1105, 1934.

symptoms that could possibly be related to the hiatus hernia. Moersch [4] found that all but 19 of 246 patients with hiatus hernia had symptoms directly attributable to the hernia. Ritvo [5] found, in a series of 60 cases, that in 14 there were no symptoms due either directly or indirectly to the hernia. Ohler and Ritvo [6] studied the clinical aspects of 136 cases of hiatus hernia. They found only 9 patients without symptoms. In 4 of these patients the hernia was small, while in the other 5 at least two thirds of the stomach was above the diaphragm. Jones [7] indicated that in some cases of hiatus hernia, regardless of size, there may be no symptoms, since a large number of cases are demonstrated accidentally.

Root and Pritchett [8] stated that 19 of their 31 patients with hiatus hernia had no symptoms referable to the hernia, but there were 14 associated gastrointestinal lesions in the asymptomatic group. In another recent paper Radloff and King [9] presented 50 cases of hiatus hernia. They found that in more than half (68 per cent) of the patients there was concomitant disease that often was responsible for the symptoms. They stated the belief that in only 30 per cent of the cases of hiatus hernia could the predominant symptoms be attributed to that lesion. However, it is not certain that the associated diseases which they present are causative of the symptoms. For instance, in 9 cases diverticulosis of the colon and diverticulum of the duodenum, ordinarily thought not to produce symptoms, were the associated diseases. Inguinal hernia (6 cases) and pulmonary tuberculosis (5 cases) do not seem to be conditions usually giving rise to symptoms that may be confused with those of hiatus hernia. A recent study by Brick [10] emphasized the frequency of associated diagnoses, another gastrointestinal lesion being found in 1 of every 4 patients with a hiatus hernia. However, when such associated lesions are found in a patient with symptoms, it may obviously be difficult to decide which lesion is causing symptoms.

Most of the studies of hiatus hernia reported are done in clinics or hospitals at which a patient presents himself because of symptoms that lead to roentgenologic investigation of the gastrointestinal tract. While a small number of patients may have such investigation as a routine

4. Moersch, H. J.: Hiatal Hernia, Ann. Otol., Rhin. & Laryng. **47**:754, 1938.

5. Ritvo, M.: Hernia of the Stomach Through the Esophageal Orifice of the Diaphragm, J. A. M. A. **94**:15 (Jan. 4) 1930.

6. Ohler, W. R., and Ritvo, M.: Diaphragmatic (Hiatus) Hernia, New England J. Med. **229**:191, 1943.

7. Jones, C. M.: Hiatal Esophageal Hernia, New England J. Med. **225**:965, 1941.

8. Root, J. C., and Pritchett, C. P.: Diaphragmatic Hernia, Cleveland Clin. Quart. **5**:203, 1938.

9. Radloff, F. F., and King, R. L.: Esophageal Hiatus Hernia, Gastroenterology **9**:249, 1947.

10. Brick, I. B.: Incidence of Hiatus Hernia and Associated Lesions Diagnosed by Roentgen Ray, Arch. Surg. **58**:419 (April) 1949.

procedure, with coincidental finding of the lesion, there is a paucity of reports which state that hiatus hernia is specifically searched for in patients without symptoms. The need for such a study has been previously indicated.[10]

The accompanying table reveals the age and sex distribution in 308 cases of hiatus hernia.[1] It will be noted that only 18 per cent of the cases involved patients below the age of 50. Furthermore, the female sex has only a slight preponderance. While in the past it was thought that the incidence in women was much greater, recent reports have not documented this impression. For instance, of 220 patients with hiatus hernias of the short esophagus type reported by Harrington,[11] 140 were males and 79 females. Master, Dack, Stone and Grishman [12] studied 57 patients with hiatus hernia, 31 of whom were males. The data on age and sex are shown since the patients studied in the present report are men of 50 years or more.

Incidence of 308 Hiatus Hernias by Sex and Age

Age	Women	Men	Totals	Per Cent by Decade	
20 to 30	1	2	3	0.97	
30 to 40	6	11	17	5.51	
40 to 50	21	16	37	12.01	
50 to 60	46	43	89	28.89	76.61
60 to 70	41	35	76	24.67	
70 to 80	41	30	71	23.05	
80 to 90	9	5	14	4.54	
Over 90	..	1	1	0.32	
	165	143	308		

Several studies to detect early gastric neoplasm, in which roentgen examinations of the stomach were done in symptomless persons, have been reported. As an incidental finding, hiatus hernia has been mentioned. Sherman [13] in 1,576 patients over 45 years of age and without gastrointestinal symptoms found "cases of hiatus hernia of various types and degrees." Rigler, studying 544 symptomless persons over 50 with achlorhydria or free hydrochloric acid of less than 30 units,[14] noted "an appreciable number of hiatus hernias, apparently symptomless." In the

11. Harrington, S. W.: Esophageal Hiatal Hernias of the Short Esophageal Type: Etiologic and Therapeutic Considerations, J. Thoracic Surg. **17**:189, 1948.

12. Master, A. M.; Dack, S.; Stone, J., and Grishman, A.: Differential Diagnosis of Hiatus Hernia and Coronary Artery Disease, Arch. Surg. **58**:428 (April) 1949.

13. Sherman, R. S.: Roentgenoscopic Survey for Asymptomatic Gastric Cancer, J. Am. M. Women's A. **3**:136, 1948.

14. Rigler, L. G.: Roentgen Examination of the Stomach in Symptomless Persons, J. A. M. A. **137**:1501 (Aug. 21) 1948.

pioneer study of this type, St. John, Swenson and Harvey [15] examined 2,413 patients over the age of 50 with no digestive symptoms of appreciable significance. They tried to include only those persons who ordinarily would not have received a roentgenologic study of the gastrointestinal tract. The fluoroscopic examination was made in the erect position only, unless something suspicious was found in the fundus, in which case the patient was examined prone. In addition to the three gastric neoplasms found, there were observed "twenty-five cases of diaphragmatic hernia, two of which were rather large." This is an incidence of hiatus hernia of approximately 1 per cent in a group of patients over 50 without gastrointestinal symptoms. Presumably, this is a minimal figure since most of the fluoroscopic examinations were done in the erect position. It can be fairly assumed that more such lesions would have been found if supplemental positional technics had been used.

CLINICAL MATERIAL

All the persons examined in this study were men over the age of 50. They were all ambulatory, apparently healthy members of a modern, well managed soldiers' home.[16] The veterans volunteered to undergo the required roentgenologic examination. Each was questioned about his health and symptoms, if any. Specific questions relating to epigastric pain, heartburn, dysphagia, regurgitation, pain in the chest or shoulder, nausea and vomiting were asked. All veterans examined had no symptoms requiring medical attention and would not have had the examination but for the present study. Their past medical records, if any, were available for study.

METHOD OF EXAMINATION

All patients were examined in the morning and had abstained from food or drink since supper the previous evening. Each subject was seated in the center of the x-ray table and given 8 ounces (227 Gm.) of an aqueous barium sulfate mixture in 1 : 1 solution. The patient was instructed to drink the mixture but to refrain from swallowing the last mouthful. He was placed in the supine position with the table horizontal. The fluoroscope was centered over the distal third of the esophagus, and the patient was instructed to swallow the last mouthful of the barium mixture, which was then observed as it passed through the esophagus. The table was then tilted to a 10 degree Trendelenburg position. The patient was instructed to raise both legs without bending the knees. This maneuver is believed to raise the intra-abdominal

15. St. John, F. B.; Swenson, P. C., and Harvey, H. D.: An Experiment in the Early Diagnosis of Gastric Carcinoma, Ann. Surg. **119**:225, 1944.

16. Major Armen Bogosian, M. C., United States Soldiers' Home, Washington, D. C., cooperated splendidly in this study.

pressure without increasing the intrathoracic pressure materially, as does the Valsalva maneuver. The esophagus and stomach were studied fluoroscopically in this position, the patient being rolled to the right or left, as indicated. Roentgenograms were made of any abnormal finding.

RESULTS

Three hundred male patients over the age of 50 without significant gastrointestinal symptoms were studied in this manner. Only four hiatus hernias, two of small and two of moderate size, were discovered. This is an incidence of 1.3 per cent of the patients examined.

COMMENT

The finding of such a small number of cases of hiatus hernia in this group is comparable to that of St. John, Swenson and Harvey,[15] previously mentioned, in a similar group of asymptomatic patients over the age of 50. They found that 1 per cent of their 2,413 patients had a hiatus hernia.

These results contrast markedly with the incidence in groups of apparently symptomatic patients. For instance, in a large general hospital where the patients were referred to the radiology section from the house and outpatient services, 308 hiatus hernias, or 8.93 per cent, were diagnosed in 3,448 roentgenologic examinations. In two series of cases in which angina pectoris had been diagnosed, the incidence of hiatus hernia was surprisingly high. Nuzum[17] reported an incidence of 25 patients with hiatus hernia in 100 private patients diagnosed as having angina pectoris. In 957 patients who had roentgenologic study in which search for hiatus hernia was a routine part of the procedure, the incidence was 12.27 per cent. Gilbert[18] presented 107 patients with anginal pain, 18, or 17 per cent, of whom had a hiatus hernia. It seems apparent that there is an appreciable incidence of hiatus hernias in groups of patients who have the type of symptoms usually considered as being present with hiatus hernia at a clinical level.

While no startling conclusions can be drawn from this study of small proportions, it appears that the incidence of hiatus hernia in asymptomatic patients is small. The finding of an incidence of approximately 1 per cent is emphasized since the study was made in the age groups in which this lesion predominates in all series and with a technic which reveals a maximal number of hiatus hernias. The study does not prove but does suggest that the finding of a hiatus hernia in patients with symptoms cannot be treated lightly. It should be evaluated

17. Nuzum, F. R.: Hernia of Esophageal Hiatus: Its Relationship to Angina Pectoris, Am. Heart J. **33**:724, 1947.

18. Gilbert, N. C.: Recurrent Esophageal Hiatus Hernia, M. Clin. North America **32**:213, 1948.

after a careful search for other lesions of the gastrointestinal tract has been made. Even when another lesion is found, one should not be too prone to dismiss the hiatus hernia as being of little significance in view of its much greater incidence in patients with symptoms.

SUMMARY

Three hundred ambulatory patients over the age of 50 and without significant gastrointestinal symptoms were examined roentgenologically for hiatus hernia. Positional technics to discover a maximal number of such lesions were applied. Only 4 patients, or 1.3 per cent, had a hiatus hernia. Since the incidence of hiatus hernia in other series of cases with symptoms is much higher, it is suggested that the presence of this lesion may be significant in explaining the symptoms.

Careful clinical evaluation, with search for other abnormalities, is required before the discovery of a hiatus hernia is dismissed as of no consequence.

ABSTRACT OF DISCUSSION

Dr. L. G. Rigler, Minneapolis: I wish to direct attention to a study which was made some fifteen years ago by Eneboe and me on pregnant women. Hiatus hernia was found in 18 per cent of the multiparous women during the period of pregnancy and in 7 per cent of the primiparae. Interestingly enough, there were no gastrointestinal symptoms that we could correlate. That is, there were more gastrointestinal symptoms among those women in whom we could not demonstrate hiatus hernia than among those in whom we could. I cite that only to indicate that there are persons in whom hiatus hernias are symptomless. We picked pregnant women at the time to demonstrate that increased abdominal pressure was a large factor in the etiology of hiatus hernia.

The figures given are a good deal higher than ours, which run about 2 per cent despite the fact that for many years we have made a strenuous effort to find hiatus hernia.

I would raise the question of whether or not you can make a sharp distinction of small hiatus hernia from so-called phrenic ampulla. We have had difficulty with that, and I wonder whether Dr. Brick has any devices by which that distinction can be sharpened

Dr. R. R. Newell, San Francisco: The top of the stomach is such an easy place to overlook disease that it has been my custom of late years always to take a roentgenogram. I am curious to note the familial nature of this disease. It develops with advancing years. In one Jewish family that I had an opportunity to examine some time ago, consisting of eleven brothers and sisters all over 50 years of age, eight of them had a hiatus hernia.

Dr. Irving B. Brick, Washington, D. C.: There are more series of this being reported, and it is being looked for more closely. The incidence in the general run of hospital patients and outpatients is increasing. There is no easy way to differentiate the small hiatus hernia from the phrenic ampulla. We felt that the lesions in our series were legitimate hiatus hernias because we tried to recognize gastric mucosa in the dilated portion above the diaphragm. Admittedly, that, too, is not always easy, and what Dr. Rigler says is very true.

OPERATIVE ACCIDENTS DURING THREE HUNDRED AND TWENTY-FIVE VAGOTOMIES

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AND
JOSEPH WEINBERG, M.D.
VAN NUYS, CALIF.

DURING major surgical procedures, precautions are taken to avoid trauma to important structures. In surgical procedures on the uterus, the ureters are cautiously avoided; in surgery of the gallbladder, one is careful not to damage the hepatic artery or the common bile duct. What are the operative dangers during vagotomy? In an attempt to answer this question, we have reviewed 325 consecutive vagotomies (258 transabdominal and 67 transthoracic) performed at Birmingham Veterans Administration Hospital between June 10, 1946 and March 10, 1949.

Weeks and Ryan reported a death on the operating table during supradiaphragmatic vagotomy which they thought resulted from an abnormal vagal reflex, although permission for autopsy was not obtained, and, to quote them, "assessment as to the cause of death must be in part speculative."[1] Moore, Chapman, Schulz and Jones reported a cardiac arrest which occurred while a transthoracic vagotomy was being performed, resulting in death postoperatively. The death was attributed to "difficulties that are apparently related to the anesthesia but that could also have resulted from hyperirritability of the autonomic nervous system, with the setting up of vago-vagal reflexes and resultant cardiac standstill."[2] Crile inadvertently inserted a finger into the stomach while isolating a totally unexposed esophagus by the transabdominal approach. This was in a 232 pound patient with a large left lobe of the liver and a high diaphragm.[3]

From the General Surgery Section, Birmingham Veterans Administration Hospital.

Sponsored by the Veterans Administration and published with the approval of the Chief Medical Director. The statements and conclusions published by the authors are the result of their own study and do not necessarily reflect the opinion or policy of the Veterans Administration.

1. Weeks, C., and Ryan, B. J.: Two Deaths Associated with Supradiaphragmatic Vagotomy, J. A. M. A. **132**:988-990 (Dec. 21) 1946.

2. Moore, F. D.; Chapman, E. P.; Schulz, M. D., and Jones, C. M.: Transdiaphragmatic Resection of the Vagus Nerves for Peptic Ulcer, New England J. Med. **234**:241-251 (Feb. 21) 1946.

3. Crile, G., Jr.: The Surgical Treatment of Peptic Ulcer, S. Clin. North America **28**:1123-1137 (Oct.) 1948.

The accompanying table is a compilation of the operative accidents which we have experienced at Birmingham Veterans Administration Hospital from June 1946 to March 1949.

The perforation of the stomach occurred in the twelfth case of the series. During an attempt to free an unusually adherent lower portion of the esophagus from its bed, a finger was accidentally pushed through the gastric wall near the cardia. This opening was closed, and the vagotomy was completed. There were no complications resulting from the perforation.

The laceration of the esophageal musculature consisted of a separation in the line of fiber of the longitudinal muscles of the lower portion of the esophagus exposing but not entering the submucosal and mucosal layers. In freeing the esophagus from its bed, the surgeon inadvertently entered the esophageal musculature and split the fibers longitudinally for a distance of about 4 cm. This was closed with interrupted

Operative Accidents in 325 Consecutive Vagotomies

Approach	Type of Accident	Number	Cause
Transabdominal 258 cases	Perforation of stomach	1	Dissection
	Laceration of esophageal musculature	1	
	Pneumothorax on right	2	
	Bleeding splenic vessels	3	Retraction
	Small laceration of liver	2	
Transthoracic 67 cases	Fractured ribs	6	Spreading of intercostal incision

sutures of no. 60 cotton, and the patient's postoperative course was uneventful.

The two pneumothoraxes on the right side occurred during the search for the right vagus nerves. In both instances the surgeon was unable to locate the nerves at the usual level just above the diaphragm, and in an effort to pick them up at a higher level the finger dissection was carried more cephalad. Sucking noises were then noted in the mediastinum through the hiatus during inspiration, and air bubbled out during expiration. In both cases the presence of a pneumothorax was recognized immediately. The operation was continued and the nerves found and segments removed. The peritoneal opening over the hiatus is not routinely sutured; however, because of the sucking wound produced by entering the pleural space, it was closed in both of these cases by interrupted sutures of no. 40 cotton. The diagnosis of pneumothorax was confirmed by roentgenologic study. Both patients recovered without other complications.

There were three instances of bleeding from the vessels at the pedicle of the spleen due to retraction. In no instance was the bleeding consequential enough to require splenectomy. In 2 cases small lacer-

ations of the liver occurred as a result of retraction or separation of adhesions to expose the hiatus. This bleeding was easily controlled by temporary pressure.

The only operative accidents occurring during the thoracic vagotomies were rib fractures produced in 6 cases by spreading the intercostal incision with the Finochietto retractor. These patients had more pain postoperatively than those in whom no ribs were fractured; however, this was much less than in the reported cases in which rib resection was performed.

There have been no cardiac arrests or other serious disturbances which we could ascribe to abnormal vagal reflexes. We have not used injection of procaine hydrochloride into the vagus nerves before removing segments from them. It is of interest that in 14 of our cases in which electrocardiographic tracings were made during vagotomy, one disclosed a wandering pacemaker and marked bradycardia when the right vagus nerve was sectioned. The other thirteen tracings showed no significant changes. These interpretations were made by Dr. Travis Winsor.

There have been no deaths during the surgical procedure in the 325 vagotomies; however, 1 patient, our eighth in the series, died on the eighth postoperative day from pneumonitis. This gives a mortality rate of 0.3 per cent for the group and 317 consecutive cases without a death, either at the time of operation or after operation.

THE TRANSABDOMINAL APPROACH

Our technic of performing the abdominal vagotomy is essentially the same as that described by Dragstedt.[4] We do, however, use a curved transverse abdominal incision about midway between the xiphoid and the umbilicus, transecting both rectus muscles. This incision, combined with a specially designed retractor[5] with a large blade, gives excellent exposure of the esophageal hiatus without the necessity of cutting the left triangular ligament. Spinal anesthesia has been used in most of the cases.

The incidence of accidents in transabdominal vagotomy may be reduced by (1) having a sound knowledge of the anatomic structures involved before attempting to perform the operation, (2) using gentle finger dissection about the esophagus while locating and removing segments of the nerves, (3) identifying and avoiding the blood vessels on the abdominal surface of the diaphragm anterior to the hiatal ring,

4. Dragstedt, L. R.; Fournier, H. J.; Woodward, E. R.; Tovee, E. B., and Harper, P. V., Jr.: Transabdominal Gastric Vagotomy, Surg., Gynec. & Obst. **85**:461-466 (Oct.) 1947.

5. Weinberg, J. A., and Kraus, A. R.: Early Results from Vagus Nerve Section in the Treatment of Duodenal Ulcer, West. J. Surg. **56**:577-583 (Nov.) 1948.

(4) avoiding sharp dissection in the mediastinal region, (5) obtaining adequate exposure by using a generous incision and an anesthetic which gives satisfactory relaxation and (6) using careful retraction.

THE TRANSTHORACIC APPROACH

Of the 67 transthoracic vagotomies, 61 were accomplished through an intercostal incision on the left, either the seventh or the eighth interspace being used. In 6 of the early cases either the seventh or the eighth rib was divided or a 1 to 2 cm. segment was removed. It is our experience that division or resection of a rib is not necessary or desirable, as adequate exposure may be obtained through an intercostal incision spread by a Finochietto retractor.

After segments of the vagi are removed, the mediastinal pleura is closed with interrupted no. 60 cotton sutures. In several instances the pleura was left unsutured, and in each case a small hydrothorax developed postoperatively.

SUMMARY

1. Vagotomy is a safe surgical procedure, as shown by a review and analysis of 325 consecutive operations performed at Birmingham Veterans Administration Hospital. There has been 1 postoperative death, a mortality rate of 0.3 per cent.

2. Cardiac arrest from the so-called vagal reflex has not been observed in any of our cases.

3. The operative accidents of pneumothorax on the right, perforation of the esophagus or stomach or bleeding from a laceration of the liver or from torn splenic vessels may be reduced by having a sound knowledge of the anatomic structures involved, by performing gentle finger dissection about the esophagus, by avoiding sharp dissection in the mediastinum and by obtaining adequate surgical exposure and careful retraction.

FOREIGN BODIES IN THE GASTROINTESTINAL TRACTS OF PSYCHOTIC PATIENTS

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ROCKLAND State Hospital has about 7,500 mentally sick patients in the various diagnostic groups. The symptoms vary, some patients having a mild condition and others being most disturbed and violent. Those who have had experience with such patients know that it is difficult to prevent certain types of episodes such as assaults, self-inflicted injuries, suicides and the ingestion of unusual and bizarre foreign bodies. The last has been instructive and dramatic, arousing skepticism and even amazement at the fact that a human being can swallow various types and sizes of unassimilable foreign bodies and live to tell the tale (fig. 1).

In the course of consultation, treatment and operations for foreign bodies in the gastrointestinal tract since September 1944, the following observations have been most impressive: the size, shape, material, weight and length of these bodies; the mild character of the symptoms and lack of complaint in some patients because of the type of mental disease; the long latent periods that may prevail before catastrophic clinical signs call for surgical therapy; the recurrence of such ingestion in some patients; the usual maintenance of comparatively good nutrition despite these bodies; their occasional unpredictable swift passage; their immobilization in other cases when just the opposite is expected and the interesting psychiatric motives for the pathologic appetites.

Generally speaking, foreign bodies may find their way into the gastrointestinal tract by accidental or deliberate ingestion, by introduction through the anus into the rectum or by migration from a neighboring organ, cavity or extremity. Accidental swallowing is by far most common. Deliberate swallowing predominates in psychotic patients, but it may result from a dare, habit, malingering for medicolegal reasons, an attempt at evasion by prisoners or prospective soldiers, professional exhibitionism or the use of bismuth or bran. Trichobezoars

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(hair balls) and phytobezoars (food balls), the latter composed mostly of vegetable and fruit fibers, may produce large foreign bodies which call for surgical therapy.

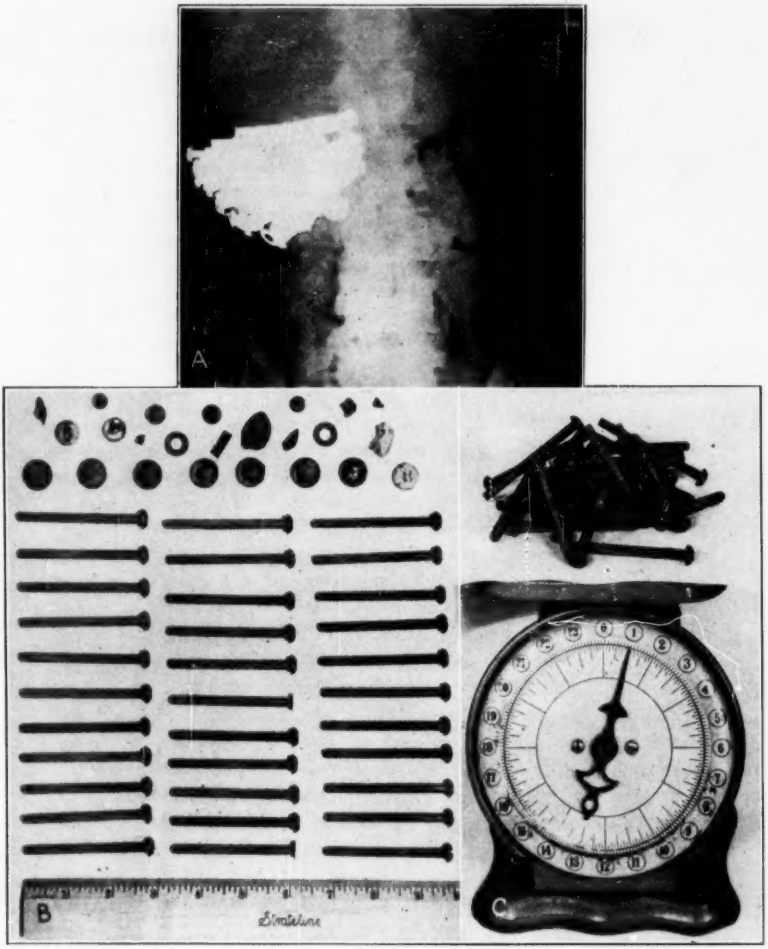

Fig. 1 (case 3703).—*A*, roentgenogram of patient described in *B* and *C*. *B*, a 23 year old man, diagnosis dementia praecox, underwent gastrotomy in 1940. There were found thirty-three 3 inch (7.6 cm.) bolts, fifteen metallic buttons, two metal washers, a peach pit, a stone and six other assorted pieces of metal. Uneventful recovery. *C*, the foreign bodies in *B* weighed 1 pound (0.5 Kg.).

ANATOMIC, PHYSIOLOGIC AND EXPERIMENTAL CONSIDERATIONS

The first case of foreign body in the intestine was reported in 1779.[1] Forty-eight cases were reported in 1927 in a previous communication [2] from the Presbyterian Hospital in New York city. They referred to accidental swallowing by patients who were free from mental disease. In 80 per cent of these the foreign bodies were passed spontaneously. The practical anatomy and physiology of the intestine and the reaction of the intestine to foreign body trauma (fig. 2)[2] were discussed. Normally the following parts of the gastrointestinal tract offer possible delay or obstruction to a foreign body: (1) the pharynx; (2) the pylorus; (3) the junction of the second and third part of the duodenum; (4) the ileocecal region because of the angular insertion of the ileum; (5) the lumen of the appendix; (6) the junction of the cecum and the ascending colon because of the presence of the "frenulum valvulae coli"; (7) flexures and haustra of the large intestine, including the rectal

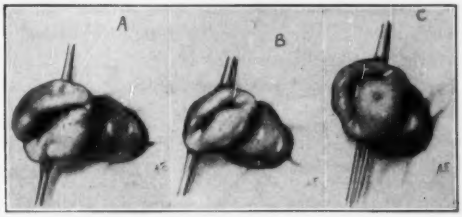

Fig. 2.—*A*, two small concavities produced on the mucosa of small intestine of a dog by gentle pricks of needle point. They were preceded by a temporary area of anemia and appeared in about two minutes, gradually becoming deeper and slowly disappearing in about ten minutes. *B*, similar troughlike reaction produced by gentle stroke of needle point. It disappeared in about fifteen minutes. *C*, concavity with surrounding area of marked anemia produced by pushing into mucosa gently with blunt end of artery clamp. The anemia persisted for about twenty minutes and the concavity fifteen minutes (Carp [2]).

ampulla and the crypts of Morgagni. In order of frequency, the pylorus, ileocecal region, rectum and sigmoid probably offer the best anatomic sites for the arrest of a foreign body. The movements of the intestine which normally are controlled centrally through intrinsic nerves and peripherally by the neuromuscular mechanism in the wall of the intestine may be grouped under the following heads: (*a*) long tonic contractions (pendular movements); (*b*) true peristaltic contractions; (*c*) rhythmic segmental contractions, and (*d*) antiperistaltic contractions, present mostly in the large intestine.

1. Baudamant: Mémoire sur des cheveux trouvés dans l'estomac et dans les intestins grêtes, J. de méd., chir., pharm. **52**:507, 1779.

2. Carp, L.: Foreign Bodies in the Intestine, Ann. Surg. **85**:575, 1927.

There is sometimes a bar to the progress of foreign bodies by one of the anatomic factors mentioned. Normally, however, the tendency is for propulsion forward by gastric and intestinal movements, which might cause the foreign body to come in intimate contact with the gastrointestinal mucosa. Nature's usual protection and reaction against this contact was shown experimentally to be a concavity with muscular boundaries on the mucosa (fig. 2). This concavity causes an increase in diameter of the intestinal lumen which facilitates propulsion forward of the foreign body by peristalsis and movement of the intestinal contents. Other authors[3] have discussed the reaction of the intestinal muscularis to mucosal trauma by foreign bodies in either barring their progress or rushing them forward. These bodies, if pointed at one end, tend to pass through the intestine with the point antiperistaltic and to be evacuated blunt end forward.[4a] Many are recovered in practically the same condition as at the time of ingestion, but the digestive juices may cause a metal object to break and other objects may be surrounded by some natural protective coat consisting of mucous, unabsorbed food or feces. Foreign bodies, varying widely in number, size and character, may travel through the distensible intestine of comparatively small diameter and cause repeated mechanical insult to the intestinal wall without producing symptoms or permanent tissue damage. Other innocent-looking bodies may precipitate acute surgical emergencies.

ROENTGENOGRAPHIC FINDINGS

Radiopaque shadows were demonstrated in all our cases. The correlation of the roentgenographic findings with those at operation was often inaccurate. For example, in hospital case 28695, a hairpin made a fairly constant appearance in the pelvis during the three months after ingestion. Contrary to expectation, it was found in the stomach at operation. A quick change in roentgenographic localization may be due to a rapid movement of a foreign body or to a shift of an intestinal loop which contains it. Hospital case 16616 showed a tender mass in the right lower quadrant with a filling defect in the cecum indicated

3. Magee, H. E., and Southgate, B. A.: Influence on Intestinal Movements of Electrolytes in Lumen of Isolated Segments, J. Physiol. **68**:67, 1929.

4. (*a*) Exner, A.: Wie schützt sich der Verdauungstract vor Verletzungen durch spitze Fremdkörper? Arch. f. d. ges. Physiol. **89**:253, 1902. (*b*) Faber, K.: Ueber Graeten als Fremdkörper im Darm und ueber Knochenverdauung, Berlin klin. Wchnschr. **35**:768, 1898. (*c*) Amboni, V.: Sulla deglutizione di aghi e spilli e sul loro decorso nel canale digerente, Ann. univ. d. med. **208**:551, 1869. (*d*) Simmons, J. S., and Von Glahn, W. C.: The Effect of Ground Glass on the Gastrointestinal Tract of Dogs, J. A. M. A. **71**:2127 (Dec. 28) 1918. (*e*) Zoja, G.: Sulla possibilità di deglutire ed evacuare aghi, Gazz. med. ital. **6**:200, 217, 283 and 329, 1867. (*f*) Carp.[2]

by a barium enema (fig. 3). In juxtaposition to the defect were three constantly superimposed hairpins. The logical diagnosis seemed to be foreign body perforation of the cecum with abscess formation. At operation the mass proved to be a carcinoma of the cecum. This was resected. The foreign bodies were not located, but they were subsequently passed. Barium contrast roentgenograms may help to determine the location of foreign bodies. At times the recognition of thin metallic

Fig. 3 (case 16616).—Roentgenogram after barium enema on a woman, aged 73, with a diagnosis of psychosis and cerebral arteriosclerosis, who had three episodes of foreign body ingestion. During the last one, she had a tender mass in the right lower quadrant and fever. The barium enema showed a filling defect in the cecum in juxtaposition to three superimposed hairpins. She was thought to have an abscess due to perforation, but she proved to have a carcinoma of the cecum which was resected. She had a recurrence in eighteen months.

objects on a roentgenogram is difficult. They may simulate bony ridges or intestinal haustra, or their shadows may be dissipated or diminished by the angle at which the roentgenogram is taken or by their distance from the tube. In such confusing cases, lateral roentgenograms are indicated.

INDICATIONS AND PREPARATION FOR OPERATION

It is well established that in most cases in which comparatively small objects have been swallowed a natural passage can be expected. With the exercise of patience and careful observation, foreign bodies are sometimes evacuated which, in the opinion of some physicians, should have been removed by operation. Occasions arise, therefore, when the most meticulous judgment is necessary in deciding whether or not to operate. Generally speaking, the urgent indications for operation are perforation of a viscus, obstruction, the presence of a toxic foreign body, such as a tube of radium, or multiplicity, size, shape and weight of foreign bodies which would make their passage improbable or impossible. In this last group are included long foreign bodies in the stomach, those which double on themselves in the stomach, those whose diameters are too large to permit their transit through the pylorus or weighty bodies which produce symptoms. The nonurgent indications for operation are the immobilization of these bodies with localized pain and tenderness, especially when this occurs in a loop of intestine which is narrowed or surrounded by adhesions, or severe symptoms and signs accompanying their progress.

The preparation for operation is standard, i. e., intubation and decompression from above when indicated, gastric lavage for foreign bodies in the stomach and the use of penicillin and intestinal antibiotics such as streptomycin and succinylsulfathiazole. Catharsis is interdicted.

OPERATIVE FINDINGS AND TECHNICS

In case 1527 there was a large perforation at the pylorus through which many foreign bodies were removed. In the remaining 10 operative cases (table 1) gastrotomies were performed, in 3 of which associated enterotomies were carried out. When there is no perforation, there may be little if any mucosal or serosal reaction. Stationary and persistent mechanical insult often produces mucosal necrosis. Perforation may cause localized and sometimes spreading infection. Foreign bodies may be coated with mucus and/or feces depending on their location in the gastrointestinal tract. Wire and steel take on a dark color and are more fragile because of the action of the digestive juices.

The guides to the localization of foreign bodies are the roentgenographic and clinical findings. Foreign bodies may be so elusive that a careful segmental palpation of stomach and intestine becomes necessary. If they have been diagnosed to be in the stomach and initial palpation at operation fails to locate them, the probability is that they have moved to the cardiac end of the stomach because of the supine position of the patient. In the case of long foreign bodies, it is possible to avoid

the necessity for a long incision into the lumen. It is good practice to mobilize one end of the foreign body against the stomach or intestinal wall, to make the smallest incision compatible with its removal and to remove through this opening other objects that may be in the same region. Thin, pointed metallic bodies, such as needles, can be pushed through the alimentary wall at operation, so that incision into a lumen becomes unnecessary. The placement of inversion sutures before the foreign body is extracted enables prompt closure. Once a foreign body is palpated, steps should be taken to avoid its release because it may slip away and become difficult to find again. Gentle manipulation of a fragile body will help prevent its breaking. An embarrassing situation may arise in which one segment eludes the operator and cannot be found.

PSYCHIATRIC CONSIDERATIONS AND MOTIVES

There are two questions which naturally arise in connection with these patients. Why do they swallow foreign bodies, and how is their ingestion possible in view of their size and the trauma they produce? Questioning of patients in an attempt to ascertain what prompted them to swallow foreign bodies failed in most instances to elicit informative response. In the second decade the motive was a desire for mischief or exhibitionism. Two patients in this group (cases 11116 and 14027) imitated each other in the simultaneous deglutition of foreign bodies of a similar nature. In other decades, 4 patients had suicidal intent. In 3 instances the swallowing was accidental. There were recurrent episodes in 5 patients. One woman (case 28695) stated that her impulse was produced by nervousness and a desire to be in the medical-surgical building where the surroundings were more to her liking. In her more lucid periods she was given insight into the harm which she was doing herself. She promised faithfully not to repeat her destructive performance. She disappointed her physicians. Within three months, three operative procedures were necessary for recurrent episodes, even though the utmost prophylactic care was used. The necessity for fourteen [5] and seven [6] celiotomies on individual patients has been reported.

There are some basic observations concerning the reasons for swallowing foreign bodies. The impulses are individualistic. There is, however, no common denominator. Among paretic and feebleminded patients and other psychotic persons with organic disease of the nervous system, there may be a regression to a level of nondevelopment, the

5. Gebert, F.: Zur Psychopathologie der Fremdkörperschlucker, München. med. Wchnschr. **76**:537, 1929.

6. Liebers, M.: Siebenmalige Laparotomie eines Psychopathen wegen Fremdkörper in Magendarmkanal, München. med. Wchnschr. **74**:815, 1927.

TABLE 1.—*Data on 11 Operative Cases**

Hospital No.	Sex	Age	Psychiatric Diagnosis	Psychiatric Symptoms	Motive for Swallowing Foreign Body	Symptoms or Signs Produced by Foreign Bodies	Roentgenologic Findings	Operative Findings	Operative Procedure	Follow-Up
1527	M	38	Dementia precox, hebephrenic	Dull, seclusive, untidy, silly, no insight, delusions, hallucinations	Not ascertained	Loss of weight, vomiting, bloody stools, no rigidity or distention	Metallic foreign bodies in the face and abdominal wall; multiple metallic foreign bodies in the stomach	(3/17/36) Perforation of pylorus 2 cm. in diameter, surrounded by dense scar tissue and omentum; stomach contained 10 tablespoon handles	Removal of foreign bodies through perforation and repair of perforation	.....
7032	F	40	Dementia paralytica	Restless, noisy, talkative, profane, distractable	Not ascertained	"Indigestion," loss of appetite, heavy feeling in stomach	Multiple foreign bodies in the stomach	(1/25/35) 10 safety pins, 6 pieces of glass, 2 spoon handles, 40 bent common pins, 1 piece of wire, 5 nails, 160 pieces of bedspring, approximate weight, 1 pound; stomach acutely inflamed and thickened; meat skewer protruding through stomach wall to omentum	Gastrotomy	5 years; recurrent episode of foreign bodies in the stomach; 4 safety pins, 6 bobby pins, 3 pieces of wire; gastrotomy with uneventful recovery
3703	M	23	Dementia precox, hebephrenic	Restless, uncooperative, resistive, irritable, seclusive, mute, spoon fed	Not ascertained	Severe abdominal pain and vomiting one quart of blood, tarry stool, shock	Metallic foreign bodies in the stomach	(10/14/40) 33 bolts of 3 inches each, 15 metallic buttons, 2 metal washers, 1 peach pit, 1 stone, 6 other assorted pieces of metal	Gastrotomy	Patient still in hospital
6863	M	22	Dementia precox, catatonic	Assaultive, disturbed, untidy, mute; negativism	Not ascertained	Patient admitted having swallowed a fork and spoon handle 2 weeks previously	Metallic and other foreign bodies in the stomach	(12/26/36) Stomach contained 1 straight handle razor, 2 horse blanket pins, 1 double-bladed pocket knife, 1 spoon handle, 1 cigaret holder, 1 key clip, 1 tie clip, 1 penny, 1 marble, 1 yale key, 1 bobby pin, 1 piece of comb, 1 screw nail, 1 piece of heavy coiled spring, shoe laces and tobacco sacks tied to one another	Gastrotomy and Enterotomy	.....
10616	F	73	Psychosis with cerebral arteriosclerosis with paranoid ideas	Suicidal attempts, delusions of persecution, fear of people wanting to kill her, history of previous ingestion of foreign bodies at age 66 and 67, pins, sewing needle, and strips of metal	Not ascertained	Pain in right lower quadrant, intermittent fever, high white cell count	3 superimposed hairpins in right lower quadrant, filling defect in cecum	(2/23/47) Carcinoma of the cecum; foreign bodies not located	One stage resection with ileotransverse colostomy	Hairpins passed subsequently (3/2/49) Recurrence of carcinoma in right lower quadrant

* Autopsy was not obtained for cases 1527, 6863, and 18521. Recovery was uneventful in all cases except 1527, in which death was due to postoperative shock, and 6863, in which death from shock occurred ten hours postoperatively.

Hospital No.	Sex	Age	Psychiatric Diagnosis	Psychiatric Symptoms	Motive for Swallowing Foreign Body	Symptoms or Signs Produced by Foreign Bodies	Roentgenologic Findings	Operative Findings	Operative Procedure	Follow-Up
30407	M	37	Dementia precox, paranoid	Depression, visual hallucinations, paranoid and suicidal ideas, confused, difficulty in concentration, impairment of memory	Accidental swallowing of gavage tube during insulin coma shock treatment	Mild spasm of upper abdominal muscles with some distention, no tenderness	Gavage tube in stomach, free ends approximated at pylorus	(1/27/49) Gavage tube in the stomach, free ends approximated at pylorus	Gastrotomy	Patient still in hospital
18521	M	26	Dementia precox, catatonic	Suicidal attempts, dull, apathetic, preoccupied	Suicide	None	Foreign bodies in the stomach	(10/27/40) Toothbrush and belt buckle in the stomach (3/3/41) Toothbrush in the stomach	Gastrotomies	(8/2/42) Death from tuberculous meningitis
22467	M	13	Dementia precox, catatonic	Tense, apprehensive, rambling, dull, poor concentration	Not ascertained	None	Metallic foreign body in stomach	(12/7/43) Spoon handle passing through pylorus into duodenum	Gastrotomy	.....
29101	F	30	Dementia precox, mixed type	Multiple delusions, confusion, lack of insight, suicidal tendencies	Suicide	Vomiting and marked abdominal distention	Stomach 3 times normal size filled with trichobezoar, open safety pin, several pieces of bent wire	(2/4/48) Entire stomach filled with hair tightly enmeshed, hair in jejunum, metallic foreign bodies as indicated in roentgenogram	Gastrotomy and Jejunotomy	(4/9/49) Patient died by hanging herself
10561	F	31	Dementia precox, catatonic	Sits in one position, no insight, mute, evacuations supervised, spoon fed, dull, retarded judgment and defective insight, assaultive, suicidal ideas; 6/8/43, swallowed a spoon and bedspring, passed spontaneously	Suicide	None	Multiple metallic foreign bodies in stomach	(12/31/41) Stomach contained 14 spoon handles, 2 bobby pins, 1 straight pin, 1 pencil	Gastrotomy	Patient still in hospital
28095	F	56	Involutional psychosis, paranoid type	Suicidal ideas, seclusive, resistive, suspicious, confused, lack of insight or judgment	Suicide; desire to be in medical-surgical building	Hematemesis, abdominal cramps, hairpin in stomach 4 months	Metallic and other foreign bodies in stomach and intestines	(11/24/48) Hairpin in stomach, lipstick container in terminal portion of ileum	Gastrotomy and Ileotomy	(12/20/48) Swallowed a string of rosary beads and a pencil 7 cm. long (1/5/49) Cecotomy and enterotomy, uneventful recovery (2/8/49) Swallowed more foreign bodies, had abdominal cramps (2/11/49) Gastrotomy for removal of thermometer, bobby pin, half of another bobby pin, half of lollypop stick; ileotomy for removal of half sewing needle; patient still in hospital

* Autopsy was not obtained for cases 1527, 6863, and 18521. Recovery was uneventful in all cases except 1527, in which death was due to postoperative shock, and 6863, in which death from shock occurred ten hours postoperatively.

TABLE 2.—*Data on 13 Nonoperative Cases**

Hospital No.	Sex	Age	Psychiatric Diagnosis	Psychiatric Symptoms	Motive for Swallowing Foreign Body	Symptoms or Signs Produced by Foreign Bodies	Roentgenologic Findings	Nature of Foreign Bodies and Time for Passage	Immediate Result	Follow-Up
11878	M	11	Primary behavior disorders	Unreliable, stubborn, severe temper, ran away from school	Mischievous	None	Many opaque foreign bodies	3 days. Rosary beads, several bullet shells	Uneventful recovery	No recurrent episode
11116	F	15	Psychosis with psychopathic personality	Quarrelsome, antagonistic, aggressive, always in trouble	Exhibitionism	None	Many opaque foreign bodies	53 days. 1 common pin, 6 screws, 14 pieces of bedspring, 1 open safety pin, piece of wire	Uneventful recovery	No recurrent episode
14027	F	18	Psychosis with psychopathic personality	Unstable, destructive, disorganized behavior	Exhibitionism in sympathy with another patient (case 11116)	None	Multiple opaque foreign bodies	9 days. 8 pieces of bedspring, 2 screws, 2 twisted pieces of metal	Uneventful recovery	No recurrent episode
22073	F	76	Psychosis, cerebral arteriosclerosis	Irritable, complaining, critical, puzzled, vague, intellectually deteriorated	"Accidental swallowing"	None	Crucifix in left lower region of abdomen	17 days. Crucifix removed from rectum after death	Died of unrelated cause—bronchopneumonia	
26274	F	31	Manic depressive psychosis, mixed type	Excitable, subject to depression, suspicious, paranoid	Not ascertained	None	Multiple opaque foreign bodies (glass) in upper part of abdomen and pelvis	7 days. Glass	Uneventful recovery	No recurrent episode
11107	M	29	Dementia praecox, paranoid type	Dull, lethargic, apathetic, rambling, olfactory, auditory and visual hallucinations	Not ascertained	.....	Many metal buttons, Jan.-Feb. 1946	Not observed	Uneventful recovery	(6/7/46) Distended abdomen. Roentgenogram revealed many opaque substances; with repeated enemas, the following were passed after several days: 1 comb, ½ comb, 1 piece of wire 2½ in. long, 1 teaspoon handle, ½ cigar butt with attached wooden holder, innumerable peach and prune pits, orange peel, banana skins, large quantity of pieces of rags and about 100 metal suspender buttons, 2 toothbrushes, wire screening ½ in. square and 4 teaspoons complete
25351	F	45	Involutional psychosis, melancholia	Rambling, irrelevant, flight of ideas, restless, agitated, hopeless, depressed, evasive, suspicious	Not ascertained	None	2 safety pins, 2 straight pins in the pelvic region	9 days. 2 safety pins and 2 straight pins	Uneventful recovery	(8/7/45) 1½ months later passed 2 safety pins and 3 straight pins Discharged 3/1/48

* Autopsy in case 10099 revealed a complete frankfurter in the upper region of the esophagus, with additional food packed into the pharynx.

Hospital No.	Sex	Age	Psychiatric Diagnosis	Psychiatric Symptoms	Motive for Swallowing Foreign Body	Symptoms or Signs Produced by Foreign Bodies	Roentgenologic Findings	Nature of Foreign Bodies and Time for Passage	Immediate Result	Follow-Up
21390	F	17	Psychosis due to encephalitis, mental deficiency	Agitated, apprehensive, rambling, assaultive	Not ascertained	None	Stomach half filled with bent straight pins, hundreds of pins scattered through intestines and rectum	2½ months. All pins passed	Uneventful recovery	No recurrent episode
27912	F	26	Dementia precox, catatonic	Stuporous, lying in one position, stoppedeating, blunted affect, evasiveness, blocking, vacuous smile	Not ascertained	None	Safety pin, 2 bobby pins in region of ascending colon	11 days. Safety pins, 2 bobby pins, paper and thread	Uneventful recovery	No recurrent episode
10009	M	43	Psychosis with epidemic encephalitis	Suicidal tendencies, tremor, salivation, irritability	Not ascertained	Severe dyspnea 1 hour after meal	None	Frankfurter not passed	Suffocation and death	
12885	M	36	Dementia precox, hebephrenic	Tense, unstable, infantile, resistive, silly, confused, insight and judgment lacking	Not ascertained	Pain in the throat	Irregular jagged wire-reenforced glass in upper region of esophagus	Not passed	Death from mediastinitis in 3 days	
5930	F	30	Dementia precox, hebephrenic	Mischievous, destructive, restless, untidy, assaultive, auditory hallucinations, thought she was poisoned and that electricity went through her body, silly, superficial	Not ascertained	Aphonia, fever, pharynx and epiglottis edematous	Irregular foreign body at level of thyroid cartilage	Not passed	Death from mediastinitis in 5 days	
17083	F	28	Psychoneurosis, reactive depression	Suicidal tendencies, untidy, dull, listless	Picked teeth with Wassermann needle	Pain in pharynx	Needle in pharynx with point cephalad	Prompt removal of needle	Uneventful recovery	

* Autopsy in case 10009 revealed a complete frankfurter in the upper region of the esophagus, with additional food packed into the pharynx.

infantile or animalism. Oral exploration, characteristic in animals, may produce pleasure in mentally deteriorated human beings. In patients who have depression, the ingestion occasionally occurs for suicidal purposes. The largest group of offenders is those who have dementia precox. They represent a group with a complicated mental context. The motives may be varied. Self mutilation accompanied with insensitivity is common. The latter is the counterpart of hysterical anesthesia, so that large, sharp and jagged objects can be swallowed without too much choking or pain. There is also the masochistic group whose self infliction of pain or punishment may occur as a reversal of a feeling of guilt or hostility to the environment. Introjective swallowers constitute another group among those with dementia precox. These will ingest foreign bodies, imagining them to be loved objects, such as penises or breasts. Sometimes the mental association, such as that of a safety pin, with the symbolic mother of the patient when a child, is particularly bizarre. Some patients have pregnancy phantasies. A man who has dementia precox may feel like a woman and have a desire for impregnation. His warped mind imagines that a swallowed foreign body will produce oral impregnation. A reversion to the infantile with its uncontrolled drive for playfulness, exhibitionism, escape from fear or a desire to arouse sympathy may produce abnormal deglutition. A number of writers[7] have discussed the latter factors in the production of these appetites. Jail inmates who wish to evade routine punishment by transfer to the infirmary often resort to this practice.[8] Occasionally, men use the device in an attempt to avoid induction into military service.

COMMENT AND ANALYSIS OF CASES

Eleven operative and thirteen nonoperative striking cases are reported herewith (tables 1 and 2). The discovery of some of these cases by mere accident or through sudden, unexpected catastrophe

7. (*a*) Cohn, M.: Verschluckte Fremdkörper, Röntgenpraxis **4**:897, 1932. (*b*) Gödel, R.: Zur Mentalität der Fremdkörperschlucker, speziell der Gefängnisinsassen, Deutsche Ztschr. f. d. ges. gerichtl. Med. **19**:63, 1932. (*c*) Kaldewey, W.: Zur Psychopathologie der Fremdkörperschlucker, J. f. Psychol. u. Neurol. **41**:309, 1930. (*d*) Kirschbaum, W.: Ueber das absichtliche Verschlucken von Fremdkörpern, Allg. Ztschr. f. Psychiat. **97**:472, 1932. (*e*) Löser, K. L.: Ueber Fremdkörperschlucker und ihre Motive, Thesis, Koenigsberg, J. Raabe, 1929. (*f*) Schum, H.: Verschlucken von Fremdkörpern und andere Arten der Selbstbeschädigung, Beitr. z. klin. Chir. **152**:276, 1931. (*g*) Tschamper, M.: Ueber Fremdkörperschlucker, Schweiz. med. Wchnschr. **71**:1607, 1941. (*h*) Macalister, D. A. P.: Foreign Bodies Swallowed Intentionally, Brit. M. J. **2**:900, 1929. (*i*) Blomquist, H. E.: Swallowed Foreign Bodies, Finska läk-sällsk. handl. **80**:583, 1937. (*j*) Zoja.[4e] (*k*) Gebert.[5]

8. Gebert.[5] Gödel.[7b] Macalister.[7h]

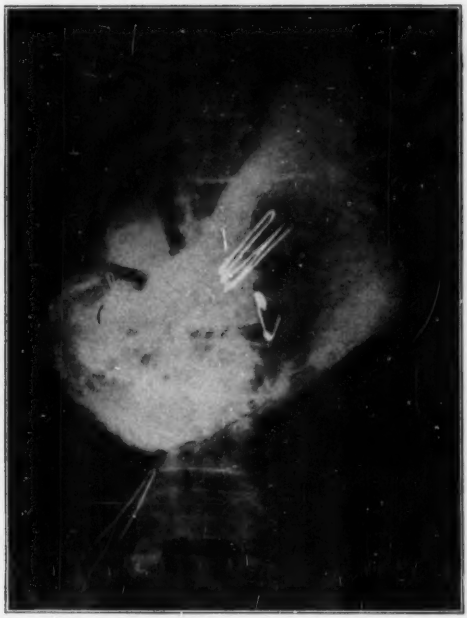

Fig. 4 (case 29101).—Roentgenogram of a woman, aged 30, with a diagnosis of dementia precox, who underwent gastrotomy and jejunotomy for removal of a huge trichobezoar. There were also a few metallic bodies in the stomach. The patient had an uneventful recovery but two months later she committed suicide by hanging.

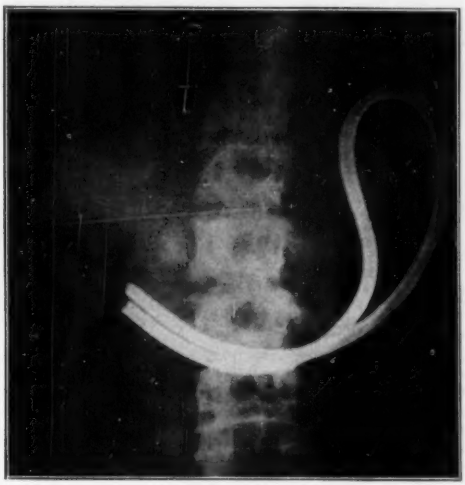

Fig. 5 (case 30407).—A 37 year old man with a diagnosis of dementia precox accidentally swallowed a gavage tube while coming out of insulin shock coma. Gastrotomy and removal of tube were carried out. Recovery was uneventful.

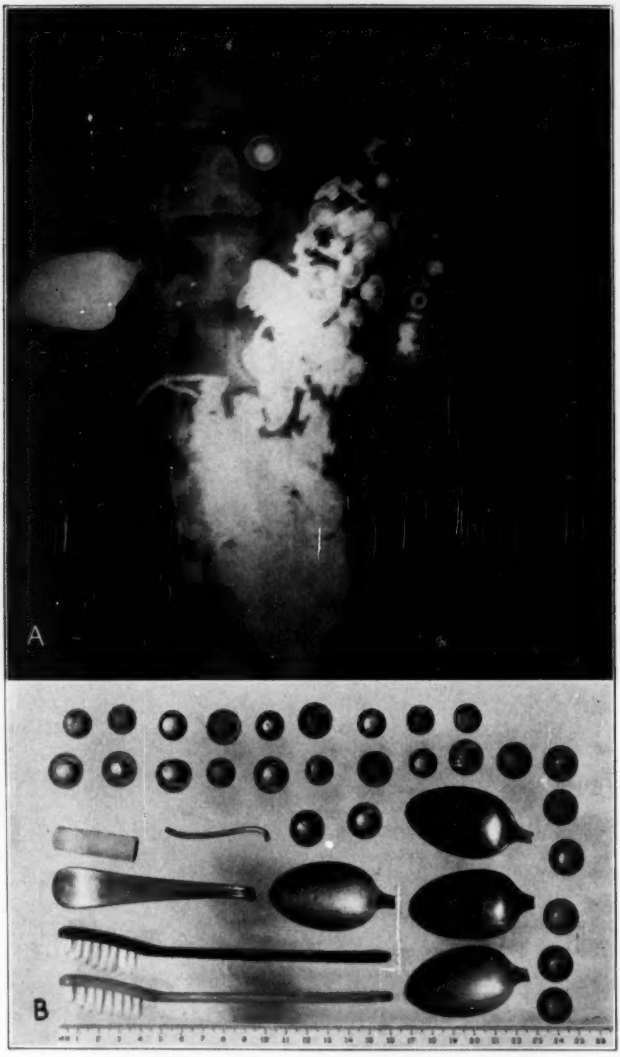

Fig. 6 (case 11107).—*A*, roentgenogram of patient described in *B*. *B*, a 29 year old Negro, with a diagnosis of dementia precox, had abdominal distention. With repeated enemas, he passed in several days a comb, half a comb, wire 2½ inches (6.35 cm.) long, teaspoon handle, four teaspoon bowls, cigar butt with attached wooden holder, innumerable peach and prune pits, orange peel, banana skins, large quantity pieces of rags, about a hundred metal suspender buttons, two toothbrushes and wire screening ½ inch (1.27 cm.) square. Recovery was uneventful. The photograph represents a few of the articles passed.

makes it likely that others were not identified. Many undoubtedly escape attention because of lack of patient cooperation, information or symptoms or because of spontaneous evacuation without observation by hospital personnel. A patient may safeguard his behavior, he may be withdrawn, mute, out of contact, disoriented or lack insight or he may be a pathologic liar. All these factors can easily confuse the physician and contribute to what superficially appears to be negligence in diagnosis.

There were 10 male and 14 female patients, of whom 18 were in the second, third and fourth decades. The diagnosis for one half of the

Fig. 7 (case 21390).—Roentgenogram of 17 year old girl with a diagnosis of psychosis due to encephalitis, whose stomach was almost half filled with bent common pins and whose entire intestinal tract contained dozens of the same foreign body. In two and a half months there was complete evacuation of the foreign bodies, with no untoward symptoms.

patients was dementia precox. Four of 5 patients in the second decade had behavior disorders associated with psychopathic personalities. The symptoms and signs in the operative cases varied with the site and type of the foreign body. The symptoms included abdominal pain, hematemesis, melena, fever, intestinal obstruction or loss of weight; the signs included peritoneal irritation or, as in 1 case, suffocation. No symptoms were noted in about one half of the patients.

Metallic foreign bodies predominated. Among these were tablespoons, teaspoons, open and closed safety pins, common straight pins, wire, nails, bedsprings, buttons, bolts, screws, a pocket knife, a straight handle razor, a belt buckle, a key, a crucifix, hairpins, rosary beads, bullet shells, needles and glass. Among the nonmetallic foreign bodies were a trichobezoar (fig. 4), a gavage tube (fig. 5), a pencil, tobacco

Fig. 8 (case 12885).—Roentgenogram of 36 year old man, with a diagnosis of dementia precox who swallowed a jagged piece of wire-reenforced glass and who died in three days of mediastinitis. Note the foreign body in the cervical portion of the esophagus and the gas in the periesophageal tissues.

sacks, shoe laces, a complete frankfurter, a toothbrush, fruit pits and skins.

The types of foreign bodies which were passed spontaneously closely approximated those found in the cases in which operation was performed. Reference is made especially to case 11107 (fig. 6) in which the patient passed an amazing collection of metallic and other foreign

bodies after repeated enemas. In another striking case (21390) (fig. 7) the stomach was about half filled with bent common pins. There were also hundreds in the entire intestine. All these passed in two and a half months without any apparent ill effect. In the nonoperative cases 9 of 13 patients had an uneventful recovery. Two patients died of mediastinitis (fig. 8), 1 of suffocation and 1 of unrelated bronchopneumonia. In the operative cases 9 of 11 patients made an uneventful

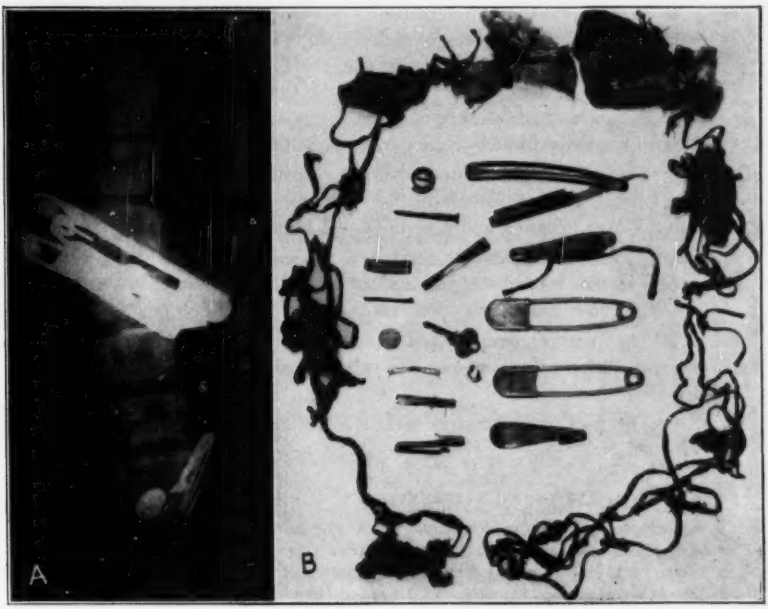

Fig. 9 (case 6863).—Roentgenogram of patient described in *B*. *B*, a 22 year old Negro, with a diagnosis of dementia precox, underwent gastrotomy and enterotomy in 1936, and there were found in the stomach a straight-handled razor, two closed horse blanket pins, a double-bladed pocket knife, a cigaret holder, a key clip, a tie clip, a penny, a marble, a Yale key, a bobby pin, a piece of comb, a screw and a piece of heavy coiled spring. In the duodenum and jejunum there were three Bull Durham tobacco sacks, tied in continuity with shoe laces. The patient died of postoperative shock.

recovery. One underwent three and another two operative procedures. Two patients died in 1936 of what was diagnosed clinically as shock (fig. 9).

SUMMARY

1. Eleven operative and 13 nonoperative cases of swallowed foreign bodies in the gastrointestinal tracts of psychotic patients are reported. Eighteen patients were in the second, third and fourth decades. One half of all the patients were given the diagnosis of dementia precox. As far as could be ascertained, one half of all the patients were symptom free, probably because of their psychiatric conditions. For that reason, sudden surgical catastrophes are common among patients of this type.

2. Bizarre metallic foreign bodies predominated. In every case except 7, the foreign bodies were multiple. They were characterized by their extraordinary composition, size, shape, weight, length or traumatic edges. In a number of instances the foreign bodies which were evacuated spontaneously were of unusual size and approximated closely those in some cases in which surgical intervention was mandatory.

3. Two patients in the operative group died of what was presumed to be shock. Four patients in the nonoperative group died, 2 of mediastinitis, 1 of suffocation and 1 of unrelated bronchopneumonia.

4. Anatomic and pathologic factors are discussed which have a direct bearing on the behavior of foreign bodies in the gastrointestinal tract, especially those which pass spontaneously.

5. The roentgenographic and clinical findings, the indications and preparation for operation and the operative finding and technics are discussed.

6. The psychiatric motives for the ingestion of foreign bodies are evaluated.

PERTINENT REFERENCES IN THE LITERATURE

Examples of Foreign Body Ingestion by Psychotic Patients.—Blomquist [7] reported 15 cases and an extensive literature. Chalk and Foucar [9] described a woman of 42 who had more than 2,500 foreign bodies removed from the stomach. Cohn [7a] reported many examples of foreign body ingestion among psychotic patients. He stressed the fact that swallowing may follow an epidemic pattern in women. Crossen and Crossen [10] cited many examples in psychotic patients. Gray and Souper's patient,[11] a woman of 41, had removed from the ascending and transverse colons 10½ hairpins, 78 common pins, 1 nail and 1 piece of steel wire ¾ inch (1.9 cm.) long. Hosford [12] described a man of 33 who had symptoms of incomplete

9. Chalk, S. G., and Foucar, H. O.: Foreign Bodies in the Stomach, Arch. Surg. **16**:494 (Feb.) 1928.

10. Crossen, H. S., and Crossen, D. F.: Foreign Bodies Left in the Abdomen, St. Louis, C. V. Mosby Company, 1940.

11. Gray, H. M. H., and Souper, H. B.: Case of Multiple Foreign Bodies in the Colon: Operation and Recovery, Brit. J. Surg. **2**:714, 1915.

12. Hosford, A. S.: Foreign Bodies in the Intestine, Brit. M. J. **1**:830, 1912.

obstruction and peritonitis. Autopsy showed wood, linens, neckties and stones in the small and large bowel. Lees's patient,[13] a woman of 25, swallowed a dinner fork 6½ inches (16.5 cm.) long. Peters[14] wrote a monograph on pointed foreign bodies in the intestine and Poulet[15] one on foreign bodies. Sachs[16] reported 52 instances of foreign bodies in the gastrointestinal tract in 19 psychotic patients, who were self assertive, hysterical and explosive. Most of the foreign bodies passed spontaneously. Schum[16f] reported cases of foreign body swallowing for self mutilation. In Stough's[17] article a man of 28 swallowed a knife 6¼ inches (16.8 cm.) long. Several months later an abdominal fecal fistula developed. The knife was removed from the fistulous tract. Wölfler and Lieblein[18] wrote a monograph on the subject, with a review of the literature from the eighteenth century up to 1909.

Examples of Foreign Bodies Passed After Long Periods.—Gellhorn[19] described a girl of 6 who swallowed two stick pins. Twenty years later she passed a mass as large as a fist. This was broken with a hammer, and the stick pins were found. In Pearb's[20] case a splinter of wood was removed digitally from the rectum which had been swallowed fifteen years previously. Smith[21] described a woman who passed a darning needle 1 11/16 inches (4.3 cm.) long after twenty years.

Unusual Migration of Ingested Foreign Bodies.—Cordier's patient,[22] a youth of 16, was operated on for two stones in the bladder. One was attached to a veil pin protruding into the bladder. David[23] reported on a man of 40 who swallowed a fish bone. He had cystitis for twenty-nine months. It was passed per urethram. Rodrigues[24] described a woman of 30 who had two bamboo sticks removed from the transverse colon. She said that they had been introduced per vaginam. Woodman[25] reported a case in which a man swallowed a darning needle and nine years later it was removed from the posterior aspect of the hip joint.

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13. Lees, K. A.: A Dinner Fork in the Stomach and Duodenum, Lancet **1**:298, 1919.

14. Peters, R. L. B.: Ueber spitze Fremdkörper in Magen-Darmkanal, Thesis, Koenigsberg, H. Jaeger, 1902.

15. Poulet, A.: Treatise on Foreign Bodies in Surgical Practice, London, S. Low, Marston, Searle & Rivington, 1881.

16. Sachs, J.: Ingestion of Foreign Bodies by Psychopathic Patients, Nord. med. **35**:1628, 1947; Automutilation Among Psychiatric Patients by Swallowing Foreign Bodies, Nord. med. **35**:1789, 1947.

17. Stough, D. F.: Knife Swallowing: Report of a Case, J. Oklahoma M. A. **11**:331, 1918.

18. Wölfler, A., and Lieblein, V.: Die Fremdkörper des Magen-Darmkanals des Menschen, Stuttgart, F. Enke, 1909.

19. Gellhorn, G.: Two Stick-Pins Retained Within the Intestinal Canal for Twenty Years, Weekly Bull. St. Louis M. Soc. **3**:470, 1909.

20. Pearb, J. F.: Foreign Body in Rectum, Lancet **2**:558, 1916.

21. Smith, H.: A Needle in the Alimentary Canal, Brit. M. J. **1**:81, 1920.

22. Cordier, A. H.: Migration of Pin from Intestine into Bladder, Am. J. Clin. Med. **14**:1001, 1907.

23. David, I.: An Errant Fishbone, Brit. M. J. **1**:166, 1918.

24. Rodrigues, J.: Report of Case from the Emery Hospital, Anand, India, Brit. M. J. **1**:995, 1911.

25. Woodman, M. S.: Tr. New Hampshire M. Soc. **162**:170, 1897.

Foreign Body Obstruction from Bismuth.—In Eccles'[26] case a bismuth ball was lodged in the rectum after a patient had been taking bismuth subnitrate for several years.

Trichobezoars and Phytobezoars in the Gastrointestinal Tract.—Heazlit[27] reported 70 cases in the literature up to 1914. Hill's patient,[28] a psychotic woman of 66, came to autopsy and a 4 inch (10 cm.) trichobezoar was found in the terminal portion of the ileum. Larimore[29] reported 2 cases of phytobezoar. Maes[30] reported a case of phytobezoar and reviewed the literature. In Noon's patient,[31] a psychotic woman of 30, intestinal obstruction developed which was due to four hair balls in the intestine.

Foreign Body Appendicitis.—Bidwell[32] found foreign bodies in 20 per cent of appendixes (pins, hairs from toothbrush, camel and human hair, fruit seeds, shot and rose thorns). Fowler[33] analyzed 63 cases.

Foreign Bodies Inserted into the Rectum.—Bonard[34] reported a man of 23 who had inserted into the rectum a piece of iron 9 inches (22.8 cm.) long. It was removed with forceps. Conlin[35] described a man of 68 who inserted into the rectum a china cup broken in two. The sphincter was lacerated. The cup was removed with pliers. Peterson's patient,[36] a man of 36, inserted a turnip 3½ inches (8.8 cm.) in diameter into the rectum. It was removed with the patient under anesthesia. Steven[37] reported on a man of 40 who inserted the neck of a bottle 8 inches (20.3 cm.) high into the rectum to relieve constipation. It was removed digitally with the patient under anesthesia.

Ingestion of Foreign Bodies on a Dare.—Genglaire[38] describes a man of 65 who swallowed 30 frogs whole. A large mass of tangled frog bones was extricated from the rectum. Pringle[39] reported on a youth of 20 who swallowed seven 1 inch (2.5 cm.) nails. At operation they were found in the ascending colon. He died from general peritonitis, and at autopsy the cecum and ascending colon were necrosed.

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26. Eccles, W. M.: A Lecture on Foreign Bodies in the Alimentary Tract, Clin. J. **44**:247, 1915.

27. Heazlit, L.: Hair balls of Stomach and Intestine, J. A. M. A. **62**:107 (Jan. 10) 1914.

28. Hill, W. B.: A Case of Hair Ball in the Intestine, Lancet **2**:1539, 1913.

29. Larimore, J. W.: Phytobezoar, M. Clin. North America **11**:499, 1927.

30. Maes, U.: Bezoars, with Report of an Additional Case of Phytobezoar, Ann. Surg. **88**:685, 1928.

31. Noon, C.: Hair Balls in Alimentary Tract, with Record of a Case of Intestinal Obstruction Due to Four Hair Balls, Brit. M. J. **1**:342, 1928.

32. Bidwell, L. A.: Foreign Bodies in the Appendix, Lancet **2**:944, 1911.

33. Fowler, R. H.: Foreign Body Appendicitis, Ann. Surg. **56**:427, 1912.

34. Bonard, N. S.: Foreign Bodies in the Rectum, Lancet **1**:185, 1917.

35. Conlin, F. M.: Foreign Body in the Rectum, J. A. M. A. **61**:2063 (Dec. 6) 1913.

36. Peterson, G.: Foreign Body in Rectum, Brit. M. J. **2**:714, 1915.

37. Steven, D.: Foreign Body in Rectum, New Zealand M. J. **16**:210, 1917.

38. Genglaire: Foreign Body in Rectum, Brit. M. J. **2**:1244, 1905.

39. Pringle, J. H.: Removal of Seven Nails from the Ascending Colon, Edinburgh M. J. **2**:463, 1909.

Accidental Swallowing of Radium.—A tube of radium was put into the nasopharynx for therapy (Carp [3]). It was swallowed accidentally and immediately removed from the duodenum, with no ill effects. A tube of radium was applied to a carcinoma of the tongue (Watson [40]). It was swallowed accidentally and removed from the small intestine, with no ill effects.

Professional Swallowing (Human Ostrich).—Launay [41] described a man who swallowed nails for exhibition. They were usually passed by rectum, but one perforated the cecum, with operative recovery. Prentiss and Waite [42] reported on a man of 30 who had been swallowing nails and tacks since the age of 7. He liked to do this for publicity. He exhibited in vaudeville three times a day. He would eat a light bulb, half a beer bottle well broken up, nails and a box of tacks. He had no symptoms or constipation; occasionally he saw glass in his stools. The day before he was examined he ingested cartridges and tacks with breakfast. Examination revealed no abnormalities, and a roentgenogram showed the foreign bodies in his stomach and intestine. Sicart [43] described a case in which a diverticulum of the esophagus enabled a man to swallow and regurgitate foreign bodies as a professional performer.

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40. Watson, J. C.: Foreign Bodies in the Gastrointestinal Tract, South California Pract. **30**:22, 1915.

41. Launay, M.: Nail in Cecum, Bull. et mém. Soc. d. chir. de Paris **45**:625, 1919.

42. Prentiss, E. C., and Waite, W. W.: Man Who Swallows Foreign Bodies, Southwestern Med. **18**:266, 1934.

43. Sicart, H.: Diverticulo digestivo profesional, Rev. españ. de med. y cir. **17**:111, 1934.

MASSIVE HEMORRHAGE FROM PEPTIC ULCER

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THE MANAGEMENT of patients with gross bleeding [1] from the upper gastrointestinal tract has become a subject of renewed interest. It is difficult to obtain facts from the literature on this subject, because such hemorrhage can be of all degrees of severity and can occur from a variety of lesions and in various manners. Comparison of reports from different authors is therefore difficult. Yet it is obvious that a change is taking place among the members of the medical profession in their view of how these patients should be managed. There is also an encouraging trend of improvement in results.

SOURCE OF BLEEDING

Costello [2] reported on 300 patients who vomited gross blood and had evidence of shock or anemia or both. Of these, 69.3 per cent bled from peptic ulcer, an additional 18 per cent from acute or chronic gastritis and 1.3 per cent from gastric carcinoma, a total of 88.6 per cent which should be considered subject to benefit by gastric resection; 8 per cent bled from ruptured esophageal varices, and 1 per cent bled from esophageal carcinoma, conditions which partial gastrectomy would not benefit. This distinction we draw now, to be referred to later.

Hoerr, Dunphy and Gray,[3] reporting 191 cases of hemorrhage from the upper gastrointestinal tract, a slightly different category, found similar percentages, viz., 85.3 per cent from peptic ulcers, gastritis and neoplasms and 7.4 per cent from esophageal varices.

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1. We do not attempt to define the terms "gross bleeding," or "massive hemorrhage." In this article they connote the rapid loss of enough blood to have obvious constitutional effects.

2. Costello, C.: Massive Hematemesis, Ann. Surg. **129**:289-298 (March) 1949.

3. Hoerr, S. O.; Dunphy, J. E., and Gray, S. J.: The Place of Surgery in the Emergency Treatment of Acute, Massive Upper Gastrointestinal Hemorrhage, Surg., Gynec. & Obst. **87**:338-342 (Sept.) 1948.

MORTALITY

The greatest variation is found in the literature under this heading, depending on how severe a degree of bleeding is included in the reports, whether surgically treated patients are included and what years the reports cover. Although Finsterer [4] advocated early operation for bleeding ulcer as far back as 1918, his advice was not generally accepted and surgery was reserved as a last desperate measure in most clinics. Accordingly, the death rate for surgically treated patients was high. Also, patients died sometimes of postoperative complications other than bleeding, their deaths raising the question of what would have happened had they not been operated on at all. Another variable is the better treatment under a conservative regimen that has been developing of recent years. If one desires to ascertain what the anticipated death rate is among patients with severe bleeding from peptic ulcer under a modern conservative regimen, one must discard reports that include years prior to the last two or three. If one wishes to discover whether surgery can still further improve the results, the evidence becomes yet more indirect.

Holman [5] collected 13 reports from the literature covering about 3,300 cases of bleeding peptic ulcer with an over-all mortality of a little over 9 per cent. Inasmuch as the mortality rates reported varied from 1 to 25 per cent, it is evident that the lower mortality rates had to do with patients who were not undergoing what all authors would call massive hemorrhage. Holman presented an additional series of 161 patients treated before 1940, with a mortality rate of 13 per cent. Amendola,[6] in describing 120 patients with massive bleeding from ulcer, noted a mortality rate of 15 per cent among those not given surgical treatment. Warren and Lanman [7] stated that under current methods of conservative treatment the expected mortality rate is 5 to 10 per cent. Our own records indicate a similar rate (table 1) among patients treated a decade ago. A recent series, reported by Fraser and West,[8] of 177 patients with severely bleeding duodenal ulcers had a mortality of 6.2 per cent, including a rate of 4.2 per cent among those treated conservatively. Costello [2] cited a mortality rate of 4 per cent among his recent

4. Finsterer, H.: The Operative Treatment of Severe Gastric Hemorrhage of Ulcer Origin, Lancet **2**:303-304 (Aug.) 1936.

5. Holman, C. W.: Further Observations on the Treatment of Bleeding Peptic Ulcer, Surgery **23**:405-409 (March) 1948.

6. Amendola, F. H.: The Management of Massive Gastro-Duodenal Hemorrhage, Ann. Surg. **129**:47-56 (Jan.) 1949.

7. Warren, R., and Lanman, T. H.: Surgery in Bleeding Peptic Ulcer: Urgent Operation and the Principle of Exclusion, Surg., Gynec. & Obst. **87**:291-298 (Sept.) 1948.

8. Fraser, R. W., and West, J. P.: The Management of Bleeding Duodenal Ulcers, Ann. Surg. **129**:209-304 (March) 1949.

patients with gross hematemesis, none of whom was operated on. In summary, it seems fair to state that even today, among patients who all would agree were undergoing gross hemorrhage from peptic ulcer, a death rate can be anticipated of about 5 per cent and often higher unless surgical intervention can lower it.

HITHERTO PROPOSED PLANS OF MANAGEMENT

In various hospitals throughout the country, plans of managing patients with acute massive hemorrhage of the upper gastrointestinal tract have evolved apparently somewhat independently. For patients with massive hematemesis, Costello [2] advocated rapid replacement of blood, early feeding (for which he employs a mixture high in protein), adequate doses of morphine, no gastric tube, no early diagnostic methods and no surgical intervention. His death rate among 73 patients was 4 per cent, compared with 25 per cent in previous years. Aaron, Lipp and Milch [9] also advocated rapid replacement of blood, giving as much as 2,000 cc. in an hour if necessary, and reevaluation of the patient at the end of three hours. If improvement is evident at that time they continue their conservative regimen, but if improvement is not evident they suggest that the patient is a candidate for immediate operation. They stated the belief that the surgical mortality rate is too high, even in competent hands, to justify the general use of gastric resection as the treatment of choice. They did not report their results. Ginsberg, Hirschleifer, Ritz and Schwartz [10] stated that the rate of transfusion in the event of massive hemorrhage can be 1,000 cc. in one and a half hours, provided that the patient does not have cardiac, nephritic or hypertensive disease. Amendola [6] proposed operation for patients over the age of 50 who show signs of hemorrhage after twenty-four hours of supportive therapy and similarly for younger patients after forty-eight hours. He mentioned other less general indications for surgery but is opposed to resection if a source of bleeding is not found after the stomach and duodenum are opened. Warren and Lanman [7] advocated urgent operation for patients over the age of 45 who continue to bleed massively from a proved peptic ulcer for more than twenty-four hours after admission, or who, having bled massively and stopped, shortly thereafter bleed again. Hoerr, Dunphy and Gray [8] emphasized the rate of bleeding as the basis for deciding when to operate. If syncope or hypotension developed despite transfusion of 500 cc. every

9. Aaron, A. H.; Lipp, W. F., and Milch, E.: Newer Aspects of Peptic Ulcer Therapy, J. A. M. A. **139**:514-520 (Feb.) 1949.

10. Ginsberg, V.; Hirschleifer, I.; Ritz, N., and Schwartz, I. R.: Replacement Therapy in Gastro-Intestinal Hemorrhage, Rev. Gastroenterol. **15**:747-756 (Oct.) 1948.

eight hours for a twenty-four hour period, they recommended operation. Dunphy and Hoerr,[11] however, demanded exact knowledge of the source of bleeding, by roentgenologic study, if necessary. They reported 1 death among 45 patients under this plan, as opposed to a death rate of 7.6 per cent in previous years. Holman [5] had two indications for operation, viz., the patient's failure to improve within twenty-four to forty-eight hours while on a strict medical regimen, and the onset of hemorrhage for the first time while he was on such a regimen, provided the ulcer was previously uncomplicated. He reported on 206 patients treated during 1940 to 1946, with a 5 per cent mortality rate. Fraser and West [8] advised operations only occasionally and only for patients over 50 years of age. Stewart, Massover, Potter and Schaer [12] resect the stomach widely within twenty-four hours of admission to the hospital for massive hemorrhage unless the patient refuses operation, has strong evidence of primary disease of the blood with a clotting defect or has evidence of cirrhosis of the liver with esophageal varices. The same group also reported that they perform resection even if no lesion is found, provided the patient has vomited blood. They gave an average of 3,600 cc. of blood to their operative patients, with no evidence of overtransfusion. Their operative mortality was 15 per cent, as opposed to 29 per cent among the group not operated on, but it is not clear whether the two groups are comparable. In the discussion of their report, Dr. William C. White advised operation only if an ulcer was shown in roentgenograms, and Dr. Gavin Miller advocated prompt operation for massive hemorrhage that does not stop in twenty-four hours if the patient is over the age of 45.

From these reports, all recent, it is clear that no accepted plan of treatment of massive bleeding was evolved. There is now general agreement that replacement of blood should be rapid, whether operation is done or not, that hemorrhage is more apt to result fatally among patients over 45 or 50 years of age than among younger patients and that bleeding which is not controlled within twenty-four to forty-eight hours becomes critical. It has seemed to us that none of these considerations hits at the heart of the matter but that an analysis of what happens to bleeding patients to make them die might make clearer exactly what we were trying to prevent when treating them and what means of therapy should be chosen.

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11. Dunphy, J. E., and Hoerr, S. O.: The Indication for Emergency Operation in Severe Hemorrhage from Gastric or Duodenal Ulcer, Surgery **24**:231-238 (Aug.) 1948.

12. Stewart, J. D.; Massover, A. J.; Potter, W. H., and Schaer, S. M.: Massive Hemorrhage from Gastroduodenal Ulcer, Surgery **24**:239-245 (Aug.) 1948. Stewart, J. D.; Schaer, S. M.; Potter, W. H., and Massover, A. J.: The Management of Massively Bleeding Peptic Ulcer, Ann. Surg. **128**:791-802 (Oct.) 1948.

OUR UNDERSTANDING OF HEMORRHAGIC SHOCK

Since the rational treatment of any pathologic process stems from an understanding of its development, it seems warranted to outline our ideas relative to the dynamics of hemorrhagic shock. In the accompanying diagram we have tried to set forth schematically the events in their proper relationship. It can be seen that we place great stress on the fact that tissue anoxia is the root of all evil and that the changes in blood chemistry are understandable sequelae rather than causes of the shock processes. It therefore seems logical to attack the problem at its root and to correct the reduced blood volume by prompt replacement of blood and by arresting the hemorrhage surgically if it does not rapidly arrest itself. This thought dominates our approach to all problems of hemorrhage, whether they have origin in peptic ulcers or elsewhere. Acidosis and other derangements are treated when they occur but not so intently as to cause us to lose sight of the true problem, that of a patient with a blood volume reduced to the point where he cannot compensate for it.

The route used and the rate of replacement are governed by the patient's needs as interpreted by the clinician with the aid of laboratory data. Most hemorrhages from ulcer have in our experience been adequately handled by means of intravenous transfusions. The use of pressure to increase the rate of delivery has often been necessary. By this method, large quantities of blood can be put into a patient in a short period. The precautions which must be observed in using this method have been outlined in a previous publication.[13] We have not yet had to resort to intra-arterial transfusion in treating bleeding peptic ulcers but stand prepared to do so should the need arise. It is, in our opinion, a method of great merit.

Study of the diagram reveals our understanding of the lethal nature of recurrent shock and secondary hemorrhage. In general, patients should not be allowed to remain in the decompensated[14] phase of shock for even short periods. Certainly the deliberate tolerance of shock as an aid to hemostasis is to be condemned. With the methods now available, it is the rare patient who need reach the hypotensive phase of shock, even in the operating room, except for a brief period immediately subsequent to a hemorrhage.

It should be pointed out, as a further argument in favor of early surgical intervention if bleeding is not immediately controlled, that it is

13. Porter, M. R.; Sanders, E. K., and Lockwood, J. S.: The Factor of Rate of Transfusion with Particular Reference to the Intra-Arterial Route, Ann. Surg. **128**:865-880 (Oct.) 1948.

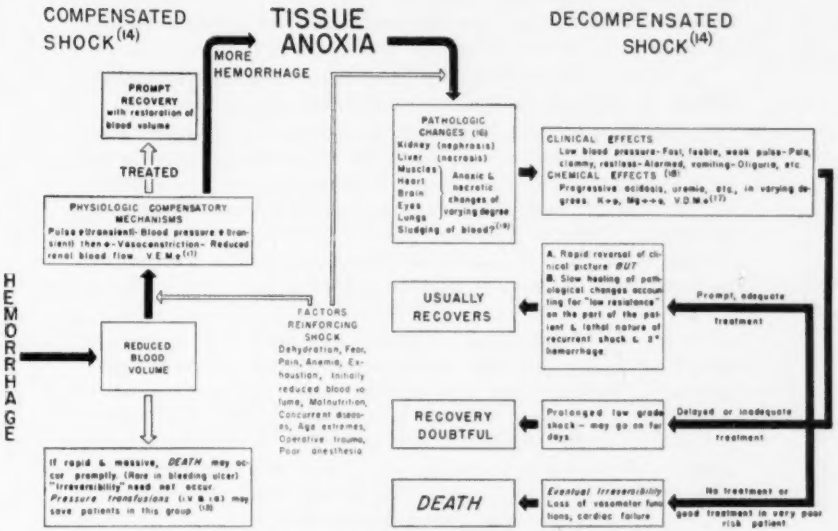
14. Keith, N. M.: Report of Shock Committee, Brit. M. Research Council, 1919, no. 6, p. 7 and following.

15 and 16. Footnotes deleted.

our clinical impression that volume for volume substitution of blood from a bank for blood lost by hemorrhage does not maintain an equilibrium. Continued major hemorrhage, with massive replacement and consequent "flushing out" of the patient's vascular bed, is a process of attrition at best and should be tolerated no longer than is clinically necessary.

PRESENT CONCEPTS OF MANAGEMENT

The concepts on which our present plan of treatment is based may be stated as follows:


COMPENSATED SHOCK(14)
TISSUE ANOXIA
DECOMPENSATED SHOCK(14)
MORE HEMORRHAGE
PROMPT RECOVERY with restoration of blood volume
TREATED
PHYSIOLOGIC COMPENSATORY MECHANISMS
Pulse ↑transient↑- Blood pressure ↑transient then ↓- Vasoconstriction- Reduced renal blood flow V.E.M.↓(17)
PATHOLOGIC CHANGES (18)
Kidney (nephrosis)
Liver (necrosis)
Muscles
Heart
Brain
Eyes
Lungs
Sludging of blood?(19)
Anoxic & necrotic changes of varying degree
CLINICAL EFFECTS
Low blood pressure- Fast, feeble, weak pulse- Pale, clammy, restless- Alarmed, vomiting- Oliguria, etc.
CHEMICAL EFFECTS (18)
Progressive acidosis, uremia, etc., in varying degree. K+↑, Mg++↑, V.D.M.↓(17)
HEMORRHAGE
REDUCED BLOOD VOLUME
FACTORS REINFORCING SHOCK
Dehydration, Fear, Pain, Anemia, Exhaustion, Initially reduced blood volume, Malnutrition, Concurrent disease, Age extremes, Operative trauma, Poor anesthesia
A. Rapid reversal of clinical picture BUT
B. Slow healing of pathological changes accounting for "low resistance" on the part of the patient & lethal nature of recurrent shock & 2° hemorrhage
USUALLY RECOVERS
Prompt, adequate treatment
RECOVERY DOUBTFUL
Prolonged low grade shock — may go on for days
Delayed or inadequate treatment
DEATH
Eventual irreversibility Loss of vasomotor functions, cardiac failure
No treatment or good treatment in very poor risk patient
If rapid & massive, DEATH may occur promptly. (Rare in bleeding ulcer) "Irreversibility" need not occur. Pressure transfusions (i.v. & i.a.) may save patients in this group.(18)

Dynamics of hemorrhagic shock.

1. The dangers to be avoided are (*a*) sudden overwhelming fatal loss of blood, which fortunately rarely occurs initially in an undepleted

17. Schorr, E.; Zweifach, B. W., and Furchgott, R. F.: Hepato-Renal Factors in Circulatory Homeostasis: III. The Influence of Humoral Factors of Hepato-Renal Origin on the Vascular Reactions to Hemorrhage, Ann. New York Acad. Sc. **49**:571-592 (May) 1948.

18. Davis, H. A.: Shock and Allied Forms of Failure of the Circulation, New York, Grune & Stratton, Inc., 1949.

19. Knisely, M. H.; Eliot, T. S., and Bloch, E. H.: Sludged Blood in Traumatic Shock, Arch. Surg. **51**:220-236 (Nov.-Dec.) 1945. Knisely, M. H., and Bloch, E. H.: Microscopic Observations of Intravascular Agglutination of Red Cells and Consequent Sludging of the Blood in Human Disease, Anat. Rec. **82**:426 (May) 1942.

person as a result of bleeding from peptic ulcer and (*b*) the effects of tissue anoxia secondary to hemorrhage, however slowly or rapidly they occur.

2. The first important step in therapy is to replace the lost blood by early adequate transfusion, without regard to the amount of blood given. Most hemorrhages so treated will stop spontaneously.

3. If the bleeding does not stop, or recurs after stopping temporarily, gastric resection with mechanical control of the bleeding point can be done without undue risk, provided the patient's condition has not been allowed to deteriorate too far. There is no need to fear operation on the patient who has been maintained in relatively good condition.

4. With an adequate blood bank available, hemorrhage from a ligatable vessel should in itself not be permitted to cause death.

5. Gastric resection is a relatively safe procedure if the patient is in good condition. However, experience has shown that resection in the presence of active bleeding is followed by more serious complications and more risk of death than it is when done electively. The order of desirability is elective resection; resection in the presence of active bleeding in an undepleted patient and resection or any form of surgical treatment in the presence of depletion and hemorrhage, this last being a poor third.

6. More to be feared than hemorrhage itself are (*a*) shock which is allowed to become prolonged or too deep; (*b*) persistence of severe anemia; (*c*) prolonged lack of nourishment; (*d*) a sudden exacerbation of bleeding in a patient who has been allowed to become depleted; (*e*) cardiac, renal, pulmonary or other defects which may become apparent after prolonged bleeding; (*f*) hasty operative procedures, necessary because the optimum time for operation was allowed to pass, and (*g*) any of the sequelae of tissue anoxia, especially if further bleeding or operative trauma is superimposed on them.

7. If the patient has associated conditions in addition to bleeding which make him a poor risk for surgical intervention, he is also a poor risk if operation is not performed.

A decade ago the controlling idea in therapy for massive bleeding was generally to avoid doing anything that would encourage the bleeding to recur or increase. Gastric resection, even when bleeding was not present, carried with it a risk of death that was not far from that of massive bleeding conservatively treated. In the presence of massive bleeding, surgical treatment was employed only when conditions became desperate. In recent years, with the improvement that has taken place in the surgery of peptic ulcer in general, it has become evident that the risk associated with resection in favorable circumstances is now less

than the risk of death from massive hemorrhage. If one can select the bleeding patients that are most apt to die of their hemorrhage and operate on them to control the bleeding while they are yet in good condition, one should be able to save lives. It is true, as Stewart and his associates say, that no one can predict surely what the course in a bleeding patient will be, but it is rare that there is not a period during which one may judge whether conservative measures are failing or are likely to fail and act accordingly.

We have adopted the following practical program:

1. The idea that the surgeon and the internist have competing methods of therapy for massive hemorrhage has been abolished. Instead, each patient is seen by both at the time of admission and followed by both until it is clear what form of therapy is indicated.

2. Patients are given blood without regard to quantity or to any fear of "blowing off the clot," but in sufficient amounts to replace what is lost and to get the patient out of shock as soon as possible.

TABLE 1.—*Cases of Severe Bleeding from Duodenal Ulcer in 1930 to 1937*

	Number of Cases	Number of Deaths	Death Rate, %
Medical therapy alone	213	12	5.6
Medical therapy plus elective surgery	20	7	35.0
Medical therapy plus emergent surgery	6	4	66.7
All cases of severe bleeding	239	23	9.6

3. In the treatment of each patient, the controlling idea is to avoid depletion. If the bleeding stops soon, of its own accord, well and good; if not, turn in time to surgery.

4. Without regard to the length of time the patient has been observed, the question stands, "Is it safe not to use surgery?"

THE RECORD OF A DECADE AGO

During the years 1930 to 1937 inclusive, 239 patients were admitted to the Presbyterian Hospital with massive hemorrhage attributed to duodenal ulcer. The total number of patients admitted to the hospital for duodenal ulcer during that period was 1,203. The great majority were admitted to the medical wards. Of the 239 patients, 26 underwent operation before being discharged and 213 received nonoperative therapy (according to a communication from C. A. Flood). Twenty-three of the 239 patients died.

Included in table 1 are some patients who did not die primarily as a result of their hemorrhage, especially among the group that underwent surgical treatment, but even if these were excluded, the alteration in the

figures would not be great. About 10 per cent of the patients treated by medical therapy alone after their admission to the hospital for massive bleeding subsequently underwent operation, usually with at least temporary benefit. The table does not reveal the mortality rate of patients with bleeding ulcers over the course of their disease but only during the time of their single stay in the hospital.

The table illustrates that only about 11 per cent of the patients were subjected to operation during their stay and only 2.5 per cent were subjected to emergent surgical treatment, i.e., while they were yet actively bleeding. Of the latter, 2 patients underwent gastric resection while they were in relatively good condition and survived. The other 4 underwent less extensive procedures in less favorable circumstances and succumbed. In no case in the entire group was surgical intervention employed as a means of treatment during the first forty-eight hours of bleeding after admission. What does not appear in the table is the fact that the conservative measures that were used were also inadequate,

TABLE 2.—*Cases of Severe Bleeding from Duodenal Ulcer in 1948*

	Number of Cases	Number of Deaths	Death Rate, %
Medical therapy alone	45	0	0
Medical therapy plus elective gastric resection	16	0	0
Medical therapy plus emergent gastric resection	15	1	6.7
All cases of severe bleeding	76	1	1.3

according to our present concepts. Blood was given too timidly in regard to both rate and amount, and the value of early feeding and of high protein diet was not appreciated.

THE RECORD OF THE YEAR 1948

In 1948, 45 patients with gross hemorrhage from peptic ulcer were treated in the hospital without operation; 16 others were treated at first conservatively and then by resection after the bleeding had well ceased, and 15 were subjected to emergent or semiemergent operations while the bleeding was yet in progress. Among all these patients there was 1 death, which was the immediate result of a cerebral accident in a patient who had had a previous stroke. This record may be compared with the results cited in table 1. During 1948 the only operation done for patients with bleeding was resection.

A program of management which includes emergent operations for bleeding patients presupposes that a special study has been made of the requirements and dangers most common in operations of this kind. Measures less extensive than gastric resection in the past did not produce results which encourage the continuance of their use. A study of the results of resection during the seven years prior to 1948 follows.

EMERGENT GASTRIC RESECTIONS, 1941 TO 1947

There were thirteen emergent resections done during the seven year span, 1941 through 1947, compared with fifteen in the year 1948. The postoperative death rate in the earlier period was 53.9 per cent, as opposed to 6.7 per cent in 1948. The postoperative complications which developed in the earlier group are significant. None died on the table or immediately after operation; 1 died twenty-four hours after operation of undetermined cause but apparently of cardiac or respiratory failure. This is the only death that could be related to operative shock or to the immediate effects of the preoperative hemorrhage. The other causes of death are shown in table 3. The conclusions to be drawn from these records are that operative shock and shock from hemorrhage are not greatly to be feared in operating on patients with bleeding ulcer but that

TABLE 3.—*Gastric Resection as Emergency Treatment for Acute Hemorrhage in 1941 to 1947* *

Case	Major Complication after Operation	Result
1	Secondary hemorrhage from ulcer	Died
2	Secondary hemorrhage from ulcer	Died
3	Secondary hemorrhage from ulcer; peritonitis from leak in duodenal stump	Died
4	Peritonitis from leak in duodenal stump	Died
5	Peritonitis from leak in duodenal stump; thrombophlebitis; possible mesenteric thrombosis	Died
6	Cardiac or respiratory failure	Died
7	Gas gangrene of abdominal wall	Died
8	Leak in duodenal stump	Survived
9	Leak in duodenal stump	Survived
10 to 13	None	Survived

* Ten patients were men and 3 women. One was 32 years old, 9 between 51 and 60, 2 between 61 and 70 and 1 was 72.

inadequate treatment of the point of bleeding and of the duodenal stump is the major error to be avoided.

More detailed scrutiny of some of these cases illustrates the special dangers to be avoided in the management of acutely bleeding ulcers.

REPORT OF CASES

CASE 1.—The patient had a large ulcer of the duodenum, 6 cm. in diameter at operation, which completely surrounded the first part of the duodenum and extended along the posterior wall of the second portion to the region of the papilla of Vater. No bleeding point was found at operation in spite of exposure of the ulcer bed. The duodenal stump was closed, the ulcer being left in. The patient did well enough after operation until the seventh day, when he suffered a severe hemorrhage. He recovered temporarily but had another hemorrhage the next day which was fatal. At autopsy an opening was found between the ulcer and a large branch of the gastroduodenal artery.

Comment.—The bleeding point could probably have been demonstrated at operation by more careful search and made secure. There was an opportunity, after the first postoperative hemorrhage, to operate again and secure the bleeding point before the fatal hemorrhage occurred.

CASE 4.—The patient was a 59 year old man, with cavities in both lungs from inactive pulmonary tuberculosis, who was watched for two days while he bled intermittently. He was finally operated on as an emergency, and at operation arterial bleeding was found to be coming from the bed of a duodenal ulcer. The bleeding vessel was ligated, and a gastric resection was done, but the closure of the duodenal stump was known to be insecure. Drainage was carried out by means of a single tube placed close to the duodenal stump. Drainage occurred from the tube on the second day after operation, indicating that the stump was leaking, and peritonitis developed. The patient died on the fourth day after operation. At autopsy the drain was found to be accurately in place, but there was fatal acute diffuse peritonitis.

Comment.—During operation the patient's condition was apparently good enough to permit careful dissection of the duodenal stump in order to secure accurate closure. Even if this were deemed inadvisable to attempt, and the stump could not be securely closed, adequate drainage could have been provided, either by means of a sump drain placed into the duodenum or by some other form of drainage which would have protected the peritoneal cavity beyond question.

CASE 8.—J. O'L., a stout patient aged 32, was watched in the hospital for twenty days while he continued to bleed. Finally his condition so deteriorated that when an acute exacerbation of the bleeding occurred he was operated on as a measure of desperation. At operation, active bleeding was found coming from the bed of the ulcer in the pancreas. A small resection was done, and the duodenal stump was closed in a manner that was recognized to be insecure, because it was thought that the patient would not stand a longer operative procedure. The obesity of the patient and the extent of the adhesions and edema about the ulcer made the operation technically difficult. On the first postoperative day, the duodenal stump leaked, but without development of diffuse peritonitis. He survived severe postoperative pneumonia and transfusion reactions and finally recovered. Four years later a jejunocolic fistula developed, which was successfully treated by surgical intervention.

Comment.—This patient bled in 1941 when operation on actively bleeding ulcers was avoided as long as possible. The result was that the surgeon in this case was finally forced into doing a difficult resection in desperate circumstances instead of at the optimum time. The patient went under the operation with a blood pressure of 95 systolic and 45 diastolic and a pulse rate of 120. The outcome might well have been a fatality, and as it was an inadequate resection was done.

EMERGENT GASTRIC RESECTIONS IN 1948

The patients in this group were often not as sick at the time of operation as were those operated on in earlier years, but that was, in part at least, owing to the fact that measures were taken to prevent them from becoming so. There was a distinct falling off not only in the mortality rate but in the rate of severe complications, i.e., from 70 to 40 per cent.

The operations in all the cases listed in table 4 were gastric resections done according to the Hofmeister technic. All but two were done through incisions in the linea alba. No more personnel were required than are usually present for gastric resections, except that in some instances an extra hospital resident was required to administer and direct the transfusions.

The cases in which severe complications occurred in 1948 illustrate the same dangers in general as those that appeared among the patients operated on in 1941 to 1947, viz., the effects of delaying operation too long and the risk of leakage from the duodenal stump and of secondary hemorrhage from the ulcer. Three patients are chosen, errors in whose management led to one or more of these difficulties.

CASE 2.—A large sthenic Italian, obviously presenting a difficult technical problem, was properly operated on before he became depleted. Time could probably have been taken at the operation to exclude the ulcer from the duodenum and secure a good closure of the stump, but this was not done. When he bled severely on his eighth postoperative day, it was correct to operate again promptly and secure the bleeding point. He did well after the second operation except for some continued leakage of bile from the duodenal stump, which soon ceased spontaneously.

CASE 3.—A man aged 70 had had hemorrhages three years from the upper part of the gastrointestinal tract, and repeated studies had failed to demon-

TABLE 4.—*Gastric Resection as Emergency Treatment for Acute Hemorrhage in 1948* *

Case	Major Complication after Operation	Result
1	Leak in duodenal stump; atelectasis; cardiac insufficiency, temporary; cerebral vascular accident	Died
2	Leak in duodenal stump; secondary hemorrhage controlled by second operation	Survived
3	Probable multiple emboli; severe paralytic ileus	Survived
4	Wound disruption with evisceration; jejunal fistula; operation to relieve these; mild postoperative bleeding	Survived
5	Secondary hemorrhage, probably from ulcer; massive thrombophlebitis with pulmonary infarct	Survived
6	Biliary fistula, maybe from gallbladder which was opened at operation	Survived
7 to 15	None	Survived

* Twelve patients were men and 3 women. One was 29 years old, 1 39, 3 between 41 and 50, 4 between 51 and 60, 4 between 61 and 70 and 2 were 72.

strate their source. He was admitted to the hospital again in 1948 for twenty days, during which he bled and obviously was losing ground in all respects, but operation was deferred for fear that no bleeding point could be found. Finally, when he was in the worst condition since his admission, operation was undertaken as a measure of desperation, and an actively bleeding artery was found in the bed of an ulcer in the descending portion of the duodenum, which roentgenologic studies had failed to reveal. He was subjected to extensive exploration before the ulcer was found, and he barely survived. Exploration should have been done sooner.

CASE 5.—The patient was in good condition at the time of operation, and it probably would have been possible to have exteriorized the ulcer from the duodenum. Exteriorization, we believe, makes secondary hemorrhage less likely to occur. The severe thrombophlebitis after operation was a deterrent to reoperation to stop the bleeding, which fortunately stopped of its own account.

PATIENTS TREATED BY DEFERRED OPERATION IN 1948

There were 16 patients who were admitted in 1948 with gross hemorrhage but who were thought safe to treat by conservative measures until an elective operation could be performed. The decision to operate on

some of these patients was made after they had been in the hospital for a week or more. They were in the hospital on an average of three to four weeks before operation. Ten were men and 5 women. Their average age was 52, lower by four years than that of the group operated on in emergencies. None of these patients died after operation, and there were only two major complications, neither of which could be attributed to the fact that bleeding had occurred before the operation. The average low red blood cell count recorded for them was 3,200,000; some of the counts were taken after the patient had received a transfusion.

Although these patients are not strictly comparable to the group that was operated on in emergencies, they do illustrate the advantages of waiting until bleeding has long ceased and an optimum condition is restored before operating, if it is safe to do so. This statement does not conflict with the fact that to wait too long is more dangerous than to operate as an emergency.

SPECIAL PROBLEMS

Our experience is not extensive enough to permit us to make categoric statements on some of the problems which are encountered in the treatment of massive bleeding in the upper part of the gastrointestinal tract, but our present opinions are as follows:

When the Source of Bleeding Is Not Known.—The commonest source of gross bleeding from the upper part of the gastrointestinal tract, other than peptic ulcer or erosion, is esophageal varices.[20] All common bleeding lesions of the stomach and duodenum except varices and blood dyscrasias are benefited by resection. It is usually possible to make a differential diagnosis, chiefly from the history, between bleeding lesions that should be resected and those that cannot be, but if doubt exists we do not hesitate to give barium sulfate by mouth to a bleeding patient at an opportune moment, sufficient to indicate whether varices are demonstrable by roentgenologic study or not. Manipulation is unnecessary in this study, and by attending the examination the surgeon or internist can aid the roentgenologist in determining how extensive an examination it is safe or desirable to make. Statistically, the resectable bleeding lesions outnumber the nonresectable ones almost tenfold. If esophageal varices cannot be demonstrated and blood dyscrasia cannot be shown and if the patient has not bled extensively from some source other than the gastrointestinal tract, then we believe that surgical exploration should be done before a bleeding patient becomes depleted under a conservative regimen, even if the site of bleeding has not been demonstrated. The patient in case 3 in the 1948 series (table 4) was

20. Costello.[2] Hoerr, Dunphy and Gray.[3]

almost lost because this policy was not followed. Lesions that bleed in the upper part of the gastrointestinal tract, undemonstrated before operation, are not infrequently found to be resectable at exploration.

When No Point of Bleeding Is Found at Operation.—Faced by this disquieting circumstance, one must be guided by attendant conditions. If it is known that the bleeding came from the stomach or duodenum and if esophageal varices are not found and blood dyscrasia is not suspected, we do not hesitate to resect. Erosions or shallow ulcers that the surgeon has failed to recognize have been demonstrated by pathologic examination in our recent experience, and these lesions, we are convinced, can bleed severely. We have even resected when it was not known for certain that the bleeding came from the stomach or the duodenum, if careful exploration of the small intestine revealed no lesion. It is possible to think of situations in which resecting blindly, so to speak, would be an error, but with care and thought exercised before and during operation, they must be rare indeed.

When the Operator Is Confronted by a Difficult Dissection Should the Ulcer Be Removed?—There is no categoric answer to this question, for so much depends on the skill of the surgeon, the condition of the patient and the degree of the technical difficulty that one can rely in such circumstances on surgical judgment alone. Because of the danger of secondary hemorrhage from the ulcer if it is left in the gastrointestinal tract, we consider it more important than we once did to exteriorize it, transfixing the bleeding point if one is found. We have had no recurrent hemorrhage when this has been done. Similarly, it is evident that an insecurely closed, inadequately drained duodenal stump constitutes a serious threat to the patient's life for some days after operation. The measures to be taken against this common cause of postoperative death are twofold: See to it that the patient is in sufficiently good condition when brought to operation and during it to permit time to dissect out a good stump of duodenum and obtain a good closure. If these steps are impossible to accomplish or seem unwise to attempt, then provision should be made to drain the insecurely closed stump as if one knew it were going to leak and were making certain that none of the leakage would find its way into the peritoneal cavity. For this purpose, the single Penrose drain or even a tube is often inadequate. We have at times used a sump drain fastened into the duodenum, if it did not rest against a bleeding point, and applied suction after operation.

When Hemorrhage Occurs After Operation.—We have had five instances of severe postoperative bleeding since 1941, proved or presumed to be from the ulcer bed. Three of the patients died without operation, one survived without operation and one survived with operation. When such bleeding takes place, for purposes of treatment it must be considered to be coming from the ulcer bed rather than from

the suture line, although the latter on rare occasions can be the source. The threat to life if the bleeding is not secured is great; on the basis of our few cases, the chances of survival are less than half. In most instances, we believe, a second operation should be done immediately, the operator going straight to the duodenal stump if the ulcer has not been exteriorized.

Thrombophlebitis, With or Without Emboli.—It is our impression that this complication is especially apt to occur after operations on depleted patients. It happened four times among the 15 patients operated on in emergency in 1948 and almost caused death in 2 of them. We have not hesitated to use dicumarol® (3,3′-methylenebis [4-hydroxycoumarin]) for phlebitis after gastrectomies, unless active bleeding was present just before operation, in which case we have preferred ligation of the superficial femoral veins.

Heart Failure.—Rapid digitalization should be done before operation if there is any doubt about the ability of the patient's heart to withstand the strain that it will undergo because of the hemorrhage, the operation and the intravenous therapy. As the majority of the patients operated on are over the age of 50, this detail of management is often important.

It is a life-saving measure also at times to have a venous pressure apparatus connected by means of a three way stopcock with the transfusion system, especially during the operation. Blood can be delivered to the patient in this manner at the rate which his heart is able to accept.[13]

Bleeding Marginal or Jejunal Ulcers.—These do not often require emergent operation, but when they do they are treated like other bleeding ulcers. We have resected two during the active phase of bleeding. We have employed either resection or vagectomy after the active bleeding has ceased, with about equally good results, but the number of our cases is too small and the follow-up, especially after vagectomy, too short to permit accurate comparison.

COMMENT

In spite of the imperfect record in 1948, it does seem clear that the patients with gross bleeding were handled in that year better than ever before. Only 1 patient (case 3, table 4) was allowed to bleed repeatedly or continuously to the point at which surgical treatment was the only recourse remaining. The chief differences between the management of these patients and those of former years, we believe, are the following:

1. In 1948 patients with massive bleeding from the gastrointestinal tract were regularly seen by surgeon and internist together when first admitted to the hospital. Their combined judgment determined whether

and at what time surgical intervention was to be employed. In general, differences of opinion after consultation were infrequent, and neither looked on operation, properly employed, as a measure to be reserved for a last resort.

2. The old principle was abandoned of keeping the patients' blood pressure low after a hemorrhage and thus often prolonging their shock. Instead, blood was given fast enough to bring them rapidly out of shock, it being realized that if depletion were avoided one could operate with reasonable safety at any time if the bleeding were not controlled. There was no longer fear of "blowing off the clot." The fear, instead, was of allowing the effects of tissue anoxia to develop rapidly or slowly, which would no longer permit surgical intervention to be carried out with safety.

3. If improvement in the patient's condition did not soon take place and, especially, if there was not good evidence that the bleeding had ceased, prompt gastric resection was usually recommended.

4. Patients who underwent urgent operation received blood freely, in amounts which averaged a total of 6 liters. This includes the blood which was given before, during and after operation. The giving of the blood was also timed with care to avoid too low arterial pressure on the one hand and too high venous pressure on the other. In the case of a patient with cardiac insufficiency, the transfusion was given under control of venous and arterial pressure readings, which were taken at frequent intervals even during operation. When necessary, blood was given through multiple venous channels. No arterial transfusions were necessary in this group.

5. The operations were not hurried. This may partly explain the fact that major postoperative complications occurred less frequently than in former years. There is yet obvious room for improvement in our record, but betterment seems to be within the range of possibility.

6. Within limits of reason, we recommended operation soonest in patients who were poor operative risks or presented difficult technical problems. An error in judgment in not seizing a fairly good opportunity to operate on them might be irreparable.

7. We are aware that the availability of a well stocked blood bank greatly lowered the risk of death following the massive hemorrhages, whether operation was done or not.

In retrospect, it is probable that the judgment of the physician and the surgeon concerning the time to operate was wrong in not more than three or four instances. The program of selection of patients for operation seems to be a practical one. No patient was lost because of postponing operation too long, and it is impossible to know whether the single death would have occurred if operation had been avoided.

SUMMARY

A plan is outlined for the management of patients with massive hemorrhage from peptic ulcer. It calls essentially for a cooperative effort of internist and surgeon from the time the patient is first seen and for selection of patients for surgical treatment.

The primary objectives of treatment were to avoid prolongation of shock and depletion, by whatever means were necessary.

During 1948, 76 patients with massive hemorrhage from ulcer were treated by conservative measures or by surgical intervention, with 1 death.

Fifteen of the entire group of 76 patients were submitted to emergency gastric resection. The problems and dangers of this type of operation are discussed.

RECURRENT SPONTANEOUS RUPTURE OF THE URINARY BLADDER

Report of the Fourth Case

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RICHARD ARTZ, M.D.
AND
LEONARD ROSETT, M.D.
BRONX, N. Y.

SPONTANEOUS rupture of the urinary bladder is unassociated with immediately antecedent trauma of sufficient force to cause perforation in the normal organ. In 1943 Marbury and Fry [1] reported the first case of recurrent spontaneous rupture of the urinary bladder. Their patient was a 37 year old white man, with chronic alcoholism, in whom spontaneous perforation occurred after a debauch in April 1940 and again in March 1941. He had had syphilis, previously treated, and they believed that the contributing factors were overdistention following alcoholism and possibly a cord bladder.

The next reported case is that of Pole [2] in 1944. His patient was a 32 year old Negro with a previous history of gonorrheal stricture and urinary retention that had required closed trochar bladder drainage. In 1940 he had been treated for an abscess of the space of Retzius, and in 1942 a large intraperitoneal abscess, presumed due to a leak in the bladder, had been drained. Three days before his present admission in June 1943, severe pain developed in the lower abdominal area while he was lifting a heavy weight. Laparotomy revealed an intraperitoneal perforation 0.5 cm. in diameter surrounded by 1 cm. of necrotic bladder wall. This was repaired, and he recovered.

The third case was reported by Oppenheimer and Druckerman [3] in 1947. This involved a 67 year old man who, after a suprapubic prostatectomy with development of urethral obstruction, on two occasions suffered a spontaneous perforation. He too recovered (see table).

1. Marbury, W. B., and Fry, W.: Spontaneous Rupture of the Urinary Bladder, Ann. Surg. **117**:760-765 (May) 1943.

2. Pole, F.: Recurrent, Non-Traumatic Rupture of the Urinary Bladder: A Case Report, Virginia M. Monthly **71**:477-478 (Sept.) 1944.

3. Oppenheimer, G. D., and Druckerman, L. J.: Recurrent, Non-Traumatic Intraperitoneal Rupture of the Urinary Bladder: Recovery, J. Urol. **57**:238-241 (Feb.) 1947.

The following case, we believe, is the fourth recorded in the English-American literature.

REPORT OF A CASE

J. W., a 31 year old white male taxi driver, was brought to the hospital a few minutes after he had been struck by an automobile on Sept. 18, 1946. Physical examination disclosed a transverse laceration 6 inches (15.24 cm.) in length just above the symphysis pubis, a partial avulsion of the skin of the left thigh and a compound comminuted fracture of the right tibia and fibula. On palpation of his abdomen there was direct and rebound tenderness throughout. Roentgenologic examination failed to reveal air under the diaphragm or pelvic fracture, and it was noted that an uncatheterized specimen of urine was grossly bloody. When he had responded satisfactorily to treatment for shock, he was taken to the operating room and his wounds were cleansed, débrided and explored while he was under thiopental sodium anesthesia. Examination of the suprapubic

Data on Reported Cases of Spontaneous Rupture of the Urinary Bladder

Cases	Year	Findings	Age	Sex	Race	Type	Associated Pathologic Process	Operation	Result
Marbury and Fry...	1943	Intraperitoneal rupture, mild peritonitis	37	M	White	Intraperitoneal	Alcoholism, syphilis	Exploration; insertion of urethral catheter	Recovered
Pole.....	1944	Diffuse purulent peritonitis	32	M	Negro	Intraperitoneal	Gonorrheal stricture	Drainage of peritoneum and bladder	Recovered
Oppenheimer, Druckerman.....	1947	Fibrinopurulent peritonitis	67	M	White	Intraperitoneal	Obstruction after prostatectomy, cystitis	Drainage of peritoneum and bladder	Recovered
Crastnopol, Artz and Rosett.....	1949	Intraperitoneal perforation, no peritonitis	34	M	White	Intraperitoneal	Trauma? 27 months before	Drainage of peritoneum and bladder	Recovered

wound revealed that the anterior rectus sheath and external oblique aponeurosis had been laid bare but were intact, and skin margins were then approximated around two soft rubber drains. The wound of the left thigh was primarily closed and reduction of the tibial fracture maintained with a 6 inch (15.24 cm.) Lane Plate. A urethral retention catheter was placed in the bladder to insure adequate urinary drainage because of the gross hematuria. Postoperatively his abdomen remained diffusely spastic and tender, and repeated scout films showed evidence of ileus. He was treated with Wangensteen suction and continuous catheterization, with a daily output of some 700 cc. of urine, which on the first postoperative day was faintly bloody.

By the fifth postoperative day these signs had receded, his temperature had fallen to 100 F., abdominal pains had subsided and a complicating pneumonia involving the right lower lobe had cleared. Hematuria was no longer present, urethral catheterization was discontinued and he began to void spontaneously. Osteomyelitis developed at the site of plating, necessitating removal of the plate, and on the fifty-fourth day in the hospital he was discharged asymptomatic to the outpatient department. He was followed at bimonthly intervals either in the fracture

clinic or in the hospital when he was admitted for change of cast and revaluation, and at no time did he have any urinary complaints.

In December 1947, while he was in the ward awaiting saucerization of the tibia for osteomyelitis, severe, crampy abdominal pains developed which were unrelieved by bowel movements and unassociated with nausea or with urinary complaints. On examination he was pale, perspiring and in obvious distress, with lower abdominal distention, spasticity and direct and rebound tenderness. Some relief was afforded by high colonic irrigation. On the following morning his symptoms recurred, and at this time he was unable to void. The bladder was emptied of 300 cc. of clear yellow urine, which gave some relief, and Wangensteen suction instituted. That evening when he strained to void, he passed a few drops of bright blood but no urine. The temperature, pulse and respirations were normal, and the white blood cell count was 18,000, with 76 per cent polymorphonuclear cells. For the next two days conservative treatment was continued, with no essential change in his general condition. The urine was normal. On the third day exploratory laparotomy was performed. At operation the peritoneal cavity was found to be filled with urine which had escaped through a 1 cm. rent in the superior surface of the bladder. The perforation was closed with a single layer of through and through interrupted chromic surgical gut sutures, a suprapubic catheter inserted through the anterior wall of the bladder and a soft rubber drain in the space of Retzius. The pathologic examination of a specimen of bladder wall removed from the site of perforation showed a "normal bladder."

On the tenth postoperative day, after an uneventful course, the urethra was dilated to 20 F., a Foley retention catheter introduced and the bladder catheter removed. On the fifteenth day the urethra was dilated to 24 F., and thereafter the patient voided spontaneously. Two months later his fracture was solidly united and he returned to his occupation as a taxi driver. He had no further urinary or abdominal symptoms.

On Jan. 29, 1949, twenty-seven months after his original injury and thirteen after repair of the perforation of the bladder, he was readmitted to this hospital. That morning he had felt an urge to void, but since he was driving he had no opportunity to do so. At 2 p. m. he was seized with sudden sharp pains in the right lower abdominal quadrant, similar to those associated with rupture of the bladder. He went to the nearest hospital, where he was catheterized and relieved. A few hours later his pain had recurred, and he went to another hospital, where he was examined and referred back to this institution for treatment. Based on our previous experience with this patient, with findings of fulness in the suprapubic region, muscle spasm and direct and rebound tenderness, a diagnosis of recurrent spontaneous rupture of the bladder was made. Cystograms were normal, but microscopic hematuria was present (15 red blood cells per high power field). Cystoscopy revealed a small perforation on the superior surface of the bladder. At operation 200 cc. of blood-tinged fluid was aspirated from the peritoneal cavity, the scarred area around the perforation excised and the defect closed with two layers of chromic surgical gut. An indwelling urethral catheter was inserted, and after its removal seven days later the patient voided spontaneously. On the thirteenth day in the hospital he was discharged. The laboratory report on a biopsy of material from around the site of perforation of the bladder was acute cystitis. It was noted on microscopic section that there was a rather pronounced increase in fibrous tissue through the muscular layers of the bladder. At a later date he was seen in the outpatient department, and at this time a no. 28 olivary-tipped catheter was easily passed. Follow-up cystourethrograms were normal.

COMMENT

It is noteworthy that fifteen months after sustaining what was probably an intraperitoneal traumatic rupture of the bladder, our patient, while at rest in the ward, had a spontaneous perforation again. Surprisingly enough, it is unusual for this to follow so long after trauma, though in Bogart's case the interval was four years, and it presupposes poor healing at the original site of injury. At operation on our patient, however, no evidence of preceding injury was present until the second episode. Apparently he had only a minimal degree of urethral stricture, a no. 28 olivary-tipped catheter being later admitted. We feel that this element may be excluded as a contributing factor.

INCIDENCE

Campbell [4] presented 55 cases of all types of trauma from Bellevue Hospital in 1929, of which 3 may have been considered spontaneous. Kahle and Beacham [5] in 1935 included 4 cases of spontaneous rupture among a total of 22 cases observed at the Charity Hospital from 1906 to 1934, 3 associated with benign prostatic hypertrophy and 1 with vesical calculus. Culp [6] in 1942, in a similar review of 32 cases of all types, found 2 which were spontaneous and associated with tuberculosis, and Bacon [7] in 1943 reported 5 among 147 cases at the Los Angeles County Hospital over a ten year period. Feigal and Polzak [8] in 1946 reported 3 cases observed at Minneapolis General Hospital over a fourteen year period, and they noted that until Stone's report [9] in 1931 only 40 cases had been recorded in the literature.

ETIOLOGIC FACTORS

Stone's classification of rupture of the bladder [9] presents succinctly the various etiologic factors involved. This is condensed as below:

I. Traumatic
   A. Penetrating wounds
   B. Concussional wounds (falls, or blows not causing penetrating wounds of bladder)

4. Campbell, M. F.: Rupture of the Bladder; A Clinical Study of Fifty-Five Cases, Surg., Gynec. & Obst. **49**:540-546 (Oct.) 1929.

5. Kahle, P. J., and Beacham, H. T.: Rupture of the Urinary Bladder, with Analysis of Twenty-Two Cases, Urol. & Cutan. Rev. **39**:385-388 (June) 1935.

6. Culp, O. S.: Treatment of Ruptured Bladder and Urethra: Analysis of Eighty-Six Cases of Urinary Extravasation, J. Urol. **48**:266-286 (Sept.) 1942.

7. Bacon, S. K.: Rupture of the Urinary Bladder: Clinical Analysis of One Hundred and Forty-Seven Cases in the Past Ten Years, J. Urol. **49**:432-435 (March) 1943.

8. Feigal, W. M., and Polzak, J. A.: Spontaneous Rupture of the Urinary Bladder, J. Urol. **56**:196-199 (Aug.) 1946.

9. Stone, E.: Spontaneous Rupture of the Urinary Bladder, Arch. Surg. **23**:129-144 (July) 1931.

II. Spontaneous
- A. Inflammatory lesions of the wall
- B. Malignant disease
- C. Obstructive changes at the vesical neck
  1. Changes in the prostate
  2. Calculi
  3. Paralytic changes
  4. Uterine and adnexial disease
  5. Changes during labor
- D. Obstructive lesions of the urethra
  1. Stricture
  2. Valves
  3. Tumors
  4. Calculi

Culver and Baker,[10] Moroney,[11] Alton,[12] Culp,[8] and Stutzin and Schurer[9] reported cases of tuberculous involvement with rupture. Bacon's review includes 4 cases of perforating carcinoma of the bladder, and Kiernan[13] another of these.

Up until 1941 there had been reported 34 cases of spontaneous rupture during pregnancy and 58 due to extension of tubo-ovarian abscesses.[1] Torpin reported a case involving a quadripara quadrigravida, who recovered, and cited 10 similar cases.[14] Chisholm and Ferguson[15] reported spontaneous rupture in a 38 year old pregnant woman, with operation and sudden death.

Wilson[16] reported a case involving a patient with tabes in which the condition was believed to be due to thinning of the wall subsequent to prolonged overdistention. Lazarus and Rosenthal's[17] and Sisk and Wear's[18] patients had urethral strictures, and 1 of Stone's a vesical calculus. Dixon and Strohl's patient[19] had syphilis of the central

10. Culver, H., and Baker, W. J.: Rupture of Urinary Bladder, J. Urol. **43**:511-531 (March) 1940.

11. Moroney, J.: A Case of Spontaneous Rupture of a Tuberculous Bladder, Brit. J. Surg. **31**:98 (July) 1943.

12. Alton, B. H.: Spontaneous Intraperitoneal Rupture of a Tuberculous Bladder, New England J. Med. **205**:1177-1181 (Dec.) 1931.

13. Kiernan, P. C.: Spontaneous Rupture of the Urinary Bladder, M. Ann. District of Columbia **9**:18-21 (Jan.) 1940.

14. Torpin, R.: Spontaneous Rupture of the Urinary Bladder in Labor, Urol. & Cutan. Rev. **44**:553-557 (Sept.) 1939.

15. Chisholm, A. E., and Ferguson, R. L.: Spontaneous Rupture of the Bladder, Brit. M. J. **2**:647 (Sept.) 1939.

16. Wilson, L. I.: Spontaneous Rupture of the Urinary Bladder in a Tabetic Patient, M. Bull. Vet. Admin. **17**:93-95 (July) 1940.

17. Lazarus, J. A., and Rosenthal, A. A.: Spontaneous Rupture of the Bladder Associated With Stricture of the Urethra, J. Urol. **36**:34-42 (July) 1936.

18. Sisk, I. R., and Wear, J. B.: Spontaneous Rupture of the Urinary Bladder, J. Urol. **21**:517-521 (April) 1929.

19. Dixon, C. F., and Strohl, E. L.: Spontaneous Rupture of the Urinary Bladder, Am. J. Surg. **33**:110-113 (July) 1936.

nervous system, and they speculated on the possibility of syphilitic ulcers as a cause. Scholl's patient [20] had obstruction of the vesical neck due to benign prostatic hypertrophy, and in Bogart's patient [21] rupture occurred four years after he had sustained an injury of his bladder. Creekmur [22] in 1937 reported spontaneous rupture of a diverticulum in a 50 year old man with obstruction of the vesical neck, and Lipow and Vogel [23] presented another patient with rupture following an alcoholic debauch.

PATHOLOGIC PROCESS

Young once said [16] that it was doubted that an unobstructed bladder would rupture because of muscular effort alone. This is unquestionably true in the great majority of instances, yet in 1935 Barnes and Steele [24] noted that 22 cases of spontaneous rupture in a normal bladder had been recorded.

Usually, in cases of unobstructed bladder some predisposing factor will be present, and overdistention, whether due to an enlarged prostate or to the loss of proprioceptive bladder sensation subsequent to alcoholism or tabes, leads to the same end result. Certainly it will be unusual for a bladder in the normal resting state to be the site of perforation. Usually the extravasation will be intraperitoneal,[8] though extraperitoneal and combined rupture will also occur. With obstruction the first predominates, the last occurring usually with pathologic involvement of the wall. In 1935 Saphir and Shapiro [25] reported replacement of muscular by fatty tissue, a process they called lipomatosis, in a patient who died of a spontaneous rupture of the bladder. Among thirty-one bladders studied they discovered fatty displacement in three. They referred to Hertig (1895), Dittrich (1922) and Fahr (1934) as having previously described this process which, in their opinion, weakens the wall and makes it more susceptible to the stresses and strains that a normal organ could easily resist. Microscopic sections surrounding the site of perforation in our patient were carefully studied but failed to

20. Scholl, A. J.: Rupture of Urinary Bladder Associated With Prostatic Hypertrophy, J. A. M. A. **106**:701-704 (Feb. 29) 1936.

21. Bogart, L. M.: Rupture of the Urinary Bladder, Am. J. Surg. **23**:442 (March) 1934.

22. Creekmur, R. L.: Diverticulum of the Bladder: Report of a Case of Spontaneous Rupture, J. Urol. **37**:363-367 (March) 1937.

23. Lipow, E. G., and Vogel, J.: Spontaneous Rupture of the Bladder, J. Urol. **47**:277-282 (March) 1942.

24. Barnes, R. W., and Steele, A. A.: Spontaneous Intraperitoneal Rupture of the Urinary Bladder, J. A. M. A. **105**:1758 (Nov. 30) 1935.

25. Saphir, O., and Shapiro, I. J.: Fatty Infiltration of the Urinary Bladder, Am. J. Surg. **29**:263-267 (Aug.) 1935.

reveal such changes. This lesion is not often mentioned in the literature and probably is of no great etiologic significance.

Only 9 to 17 pounds (4 to 7.7 Kg.) may be enough to cause a break in the substance of the bladder.[26] Usually the fundus and the posterior wall are involved, where, because of the arrangement of the muscle fibers and the weakness of mucosal support, resistance is lower. It is here, too, that the bladder first distends.[27] Stone found that in 12 of 30 cases rupture occurred at the fundus, in the midline, and in only 1 at the base. Campbell noted that in 37 it occurred on the dome, in 3 on the floor, in 4 at the vesical outlet and in 1 on the posterior wall.

MORTALITY

Until recently the mortality has been appalling. Up to 1900 the mortality in all cases was 78.9 per cent.[15] Culp [6] had a total mortality of 57 per cent in 28 cases of rupture due to all causes in which exploration was carried out. Mark [28] in 1933 stated that the mortality was 11 per cent in the first twelve hours and 55 per cent after twenty-four hours. Campbell's mortality was 63.6 per cent, or 73.5 per cent for the intraperitoneal and 49.2 per cent for the extraperitoneal varieties. Today, however, the picture has changed considerably, and the mortality figures more nearly approach those due to peritonitis of other causes.

DIAGNOSIS

The diagnosis will be determined by the history, physical findings and roentgen and laboratory studies, and symptoms will vary with the site of perforation. The patient may present a history of gradually increasing frequency of urination with dysuria and nocturia, a history of gonorrheal infection and stricture or one of preceding hematuria and dysuria. There may be a history of treated syphilis or tuberculosis or of a recent alcoholic debauch. Cases in which the last has occurred will probably most often fall into the traumatic rather than the spontaneous group. With the sudden onset of lower abdominal pain, hematuria, oliguria, dysuria, urgency, nausea, vomiting and then chills, fever and abdominal distention, the diagnosis is to be suspected. In the extraperitoneal group of cases ecchymosis or widespread cellulitis of the abdominal wall, flanks, and thighs may appear. In the intraperitoneal group rigidity of the abdomen, with or without distention, tenderness and rebound tenderness or evidence of free abdominal fluid may be present. Lipow and Vogel

26. de Tarnowsky, G.: Rupture of the Bladder: A Plea for its Early Diagnosis and Treatment, J. A. M. A. **95**:476-483 (Aug. 16) 1930.

27. Whitby, M.: Spontaneous Rupture of the Urinary Bladder, South African M. J. **18**:229 (July) 1944.

28. Mark, E. G.: Intravenous Urography in the Diagnosis of Rupture of the Bladder, J. A. M. A. **100**:42 (Jan. 7) 1933.

described a boggy, rebound sensation felt in the rectum by the examining finger as an aid in the diagnosis of free abdominal fluid. In 25 per cent of all cases shock will be present.[4]

Various adjunct methods are used as an aid to diagnosis. At this institution cystograms and intravenous pyelograms are usually the first procedures utilized. In our hands, however, it has been the cystoscopic examination which has been the most informative, and in our last 2 cases the diagnosis was so made. In the case presented cystograms were normal while cystoscopy revealed the perforation.

Introduction of a known quantity of fluid into the bladder, with measured return, is inaccurate and misleading. If the opening is minute, little difference will be noted, and if it is large, evacuation of peritoneal collections will again be misinforming. Bacon found only seven normal or inconclusive cystograms in a series of one hundred and twelve done for diagnosis of ruptured bladder, while cystoscopy aided in 1 case. Weyrauch and Peterfy [29] advocated cystometrograms and cystograms after measured fluid return. De Tarnowsky [26] suggested cystoscopy and the Vaughn-Rudnik pneumoradiography test. He found that in 34 of 50 cases correct, in 10 delayed and in 6 incorrect diagnoses were made. Others [30] stress the value of flat plate roentgenograms in the determination of renal outlines, intravenous pyelograms in showing extravasation and air injection studies.

TREATMENT

Concerning treatment, little need be said. Syme, the English surgeon, is said to have been the first to operate successfully for an intraperitoneal rupture of the bladder, in 1848.[20] Campbell stated that age, degree of shock, extent and type of injury, infection and, probably most important, the rapidity with which operative intervention is instituted determine the ultimate outcome. There can be little difference of opinion concerning the importance of these factors. In one series [5] 20 per cent of the patients operated on in twelve hours died, and 85 per cent of those operated on after two days died. In another [26] 26 per cent died when operated on in twenty-four hours and 45 per cent of those operated on later than this.

Suture of the rent is not imperative, though desirable.[31] Suprapubic cystostomy should always be done, and with this drainage of the

29. Weyrauch, H. M., Jr., and Peterfy, R. A.: Tests for Leakage in the Early Diagnosis of the Ruptured Bladder: Use of Cystometrograms, J. Urol. **44**:264-273 (Sept.) 1940.

30. Butler, E.; Sullivan, J. R., and Birnbaum, W. D.: Radiographic Evidence an Indispensable Aid in the Diagnosis of Intraperitoneal Rupture of the Bladder, West. J. Surg. **43**:410-413 (July) 1935.

31. Culp.[6] Bacon.[7]

peritoneal cavity if it is involved as well as of the perivesical space. Multiple incisions of the abdominal wall, perineum and thighs may be necessary in the presence of long-standing extraperitoneal infiltration.

The general supportive therapy will be directed toward the peritoneal involvement that is immediate in the intraperitoneal group of cases and follows on long-standing extraperitoneal perforation. Wangensteen suction, intravenous administration of fluids, including blood in the treatment of shock, and the sulfonamides, penicillin and streptomycin will be used as indicated. Definitive surgical treatment will be directed toward the correction of any contributing abnormality, frequently a chronic obstructing process.

With these measures, the mortality has been progressively lowered in pace with that of peritonitis due to other causes. This constitutes another tribute to the strides made by medicine in an understanding of basic pathologic processes and the development of antibiotics and rational therapeusis.

SUMMARY

We have presented the fourth reported case of recurrent spontaneous rupture of the urinary bladder in a 33 year old man twenty-seven months after his original injury. In our patient there was little or no obstructive element or intrinsic disease process. It was noted at operation that perforation had occurred through an area of scarring which represented poor healing of the originally involved site. Excision should effect a cure.

The literature on spontaneous rupture of the urinary bladder is reviewed.

TECHNIC, INDICATIONS AND VALUE OF POSTOPERATIVE CHOLANGIOGRAPHY

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THE EXPLORATION of the liver and its excretory bile ducts by means of contrast roentgenography has developed into an exact science. Just as urograms have transformed urology from a suppositional to a precision specialty, so cholangiograms have displaced the haphazard methods which have been employed in recognizing pathologic dysfunctions of the biliary system. The importance of cholangiography cannot be overemphasized.

HISTORICAL OBSERVATIONS

The early literature on cholangiography contains sporadic reports from various parts of the world. Reich[1] in 1918 introduced a mixture of "petrolatum and barium paste" into an external biliary fistula and obtained an accurate roentgenographic pattern of the bile ducts. In January of 1922 Tenney and Patterson[2] visualized an incarcerated ampullary stone by introducing bismuth paste into a persistent external biliary fistula. Unfortunately the thick paste plugged the bile ducts, and the resulting cholangitis and cholemia did much to discourage further development of this procedure in North America.

During November of 1922, Carnot and Blamoutier,[3] of France, reported the injection of "bismuth mush" into an external fistula with complete visualization of the larger bile ducts and localization of an

From the departments of surgery and radiology, University of Utah Medical School and R. Groves Latter Day Saints Memorial Hospital.

1. Reich, A.: Accidental Injection of Bismuth Paste and Petrolatum into Bile Ducts, J. A. M. A. **71**:1555 (Nov. 9) 1918.

2. Tenney, C. F., and Patterson, S. H.: Injection of Bile Ducts with Bismuth Paste and Observations on Flow of Bile, J. A. M. A. **78**:171-173 (Jan. 21) 1922.

3. Carnot, P., and Blamoutier, P.: Intermittent Biliary Fistula, Bull et mém. Soc. méd. d. hôp. de Paris **46**:1553-1557, 1922.

incarcerated stone in the stump of the cystic duct. Lanari and Squirru,[4] of Argentina, in 1924 introduced iodized oil (lipiodol®) directly into a hyatid cyst of the liver and were surprised when they obtained complete visualization of the bile ducts. In the same year Dunet[5] used a solution of sodium bromide for outlining the course of a fistulous tract which opened in the right flank and found that it communicated with the common bile duct.

Cotte,[6] of Lyon, in 1925 clearly outlined a choledochal stone by injecting iodized oil into a postoperative fistula. Kempeneer[7] in 1926 made repeated studies on a patient with a draining biliary sinus. On one occasion he used iodized oil and was able to localize the obstruction, but the details were so poor that he could not determine the nature of the obstructive agent. He repeated these studies, employing an aqueous solution of sodium iodine, and was able to outline the offending calculus. In 1927 Piccinino and Pazienza,[8] of Italy, demonstrated a choledochal stone by using a halogenated oil, called "gelobarium," and they were greatly impressed by the accuracy of their studies.

Walzel,[9] of Vienna, in 1927 reported 4 cases of persistent external biliary fistulas, and he was able to locate the obstructing stones in each instance. On one occasion he employed a solution of potassium iodide as the contrasting agent; the resulting pains and shock convinced him that this solution was much too irritating for clinical use. During the same year, Mallet-Guy, Beaupère and Armanet,[10] of France, reported on the use of iodized oil in outlining fistulous tracts resulting from operation on the biliary system. Cotte[6] in 1929 suggested the roentgenologic exploration of the biliary tract by the introduction of iodized oil into cholecystostomy and choledochostomy drainage tubes. Ginsburg[11] in 1930 published an excellent treatise on "lipiodol studies of

4. Lanari, E. L., and Squirru, C. M.: Roentgenology of Biliary Passages (after Lipiodol Injections), Rev. asoc. méd argent. **37**:125-127, 1924.

5. Dunet, cited by Hunt, H. B.; Hicken, N. F., and Best, R. R.: Am. J. Roentgenol. **38**:542-563, 1937.

6. Cotte, G.: Sur. l' exploration radiologique des voies biliares avec injection de lipiodol après cholécystostomie ou cholédocotomie, Bull et mém Soc nat de chir. **55**:863-871, 1929.

7. Kempeneer, P.: Kuste du pancreas, J. de chir. et ann. Soc. belge de chir. **26**:59-64, 1927.

8. Piccinino, G., and Pazienza, M.: Iniezione con sostanza opaca di fistola biliare, Arch. di radiol. **3**:939-943, 1927.

9. Walzel, P.: Ueber de radiologische Beurteilung postoperativer Gallenfisteln, Beitr. z. klin. Chir. **139**:155-161, 1927.

10. Mallet-Guy, P.; Beaupère, and Armanet: Sur les complications possibles des injection de lipiodol dans les fistules biliares, Lyon méd. **140**:215-220, 1927.

11. Ginsburg, L., and Benjamin, E. W.: Lipiodol Studies of Postoperative Biliary Fistulae, Ann. Surg. **91**:233-241, 1930.

postoperative biliary fistulae." A similar report appeared in England, when Gabriel [12] suggested that "the patency of the common bile duct" could be determined roentgenographically by studies with iodized oil.

Since that time many contributors, including Overholt,[13] Troup,[14] Mirizzi,[15] Sturm,[16] Kretchmar,[17] Judd and Phillips,[18] Thorlakson,[19] Saralegui,[20] Best,[21] Hicken,[22] Hunt,[22d] Robins and Hermanson,[23] McGowan,[24] Colp,[25] Doublet [25] and Walters,[26] have improved the technic of postoperative cholangiography, thereby enhancing its value.

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12. Gabriel, W. B.: Proof of Patency of Common Bile Duct by Injection of Lipiodol, Lancet **1**:1014-1015, 1930.

13. Overholt, R. H.: Biliary Tract Visualizations with Radiopaque Oils, Surg., Gynec. & Obst. **52**:92-97, 1931.

14. Troup, R. L.: Visualization of Biliary and Pancreatic Ducts by Use of Sodium Iodide, Radiology **18**:139-141, 1932.

15. Mirizzi, P. L.: La cholangiografia durante has operaciones de has vias biliares, Boly trab. de la Soc. de cir. Buenos Aires **16**:1133-1161; 1932.

16. Sturm, F.: Experiences with Cholangiography, Zentralbl. f. Chir. **59**:891-896, 1932.

17. Kretchmar, A. H.: Postoperative Visualizations of Biliary Tract with Radiopaque Oils, Am. J. Surg. **21**:383-389, 1933.

18. Judd, E. S., and Phillips, J. P.: Patency of Biliary Ducts Determined by Radiopaque Oil Injections Through "T" Tube Previously Placed in the Common Bile Duct for Prolonged Drainage, Surg., Gynec. & Obst. **57**:668-671, 1933.

19. Thorlakson, P. H. I., and McMillan, J. C.: Common Duct Obstructions: Lipiodol Studies of Cholangectasia Showing Effects of Prolonged Drainage, Canada. M. A. J. **31**:265-269, 1934.

20. Saralegui, J. A.: New Technic and Results of Cholangiography, Am. J. Roentgenol. **32**:167-170, 1934.

21. Best, R. R., and Hicken, N. F.: Biliary Dyssynergia, Surg., Gynec. & Obst. **61**:721-734, 1935.

22. (*a*) Best, R. R., and Hicken, N. F.: The Nonoperative Management of Remaining Common Duct Stone, J. A. M. A. **110**:1257-1261 (April 16) 1938. (*b*) Hicken, N. F.; Coray, Q. B., and Orem, J. F.: Postoperative Cholangiography, Rocky Mountain M. J. **38**:709-714, 1941. (*c*) Hicken, N. F.; White, L. B., and Coray, Q. B.: External Biliary Fistulae: A Study of Twenty-Three Cases, Surg., Gynec. & Obst. **74**:828-835, 1942. (*d*) Hunt, H. B.; Hicken, N. F., and Best, R. R.: Exploration of the Biliary Tract by Cholangiography, Am. J. Roentgenol. **38**:542-563, 1937.

23. Robins, S. A., and Hermanson, J.: Cholangiography Modified Technic for X-Ray Visualizations of the Bile Ducts During Operation, Surg., Gynec. & Obst. **62**:684-688, 1936.

24. McGowan, J. M., and Keeley, J. K.: Pathological Physiology of Biliary Drainage, Surg., Gynec. & Obst. **84**:174-180, 1948.

25. Colp, R.: Treatment of Postoperative Biliary Dyskenesia: Eight Cases of Endocholedochal Sphincterotomy, Gastroenterology **7**:414-429, 1946.

26. Walters, W., and Thiessen, N. W.: Visual Methods of Studying the Physiology of the Common Bile Duct: The Problem of Pancreatitis and Sphincteritis, Proc. Staff Meet., Mayo Clin. **9**:772-775, 1934.

TECHNIC

Postoperative cholangiograms are usually made from the fifth to the eighth postoperative day, at which time the patient can be easily transported to the roentgenologic department. Such a delay permits the hepatobiliary system to recover partially from the surgical trauma, thereby making estimates of potential functions much more accurate.

The patient is placed on the x-ray table in the supine position so that the area from the fourth thoracic to the fourth lumbar vertebra will be reproduced on the film. All technical factors such as distance, milliamperage, voltage and time of exposure are predetermined according to the stature of the patient, and the necessary mechanical adjustments are all made before the injections are begun. Such a routine permits the radiologist to make instantaneous exposures during any phase of the ductal injections. While the roentgenogram is being taken, the patient should maintain a period of apnea, thereby arresting motion of the thoracic cage, which greatly minimizes roentgenologic distortions.

During the past fourteen years we have had an extensive experience with most radiopaque mediums and have found iodopyracet injection (diodrast® solution 35 per cent, of Winthrop-Stearns, Inc.) to be the most satisfactory cholangiographic agent. Iodopyracet injection is nonirritating to local tissues and is freely miscible with bile, and the resulting mixture has such a high degree of radiopacity that even a minute amount will provide an accurate roentgenologic pattern of the smallest biliary radicles.

How much iodopyracet should be injected into the ducts? No definite rule can be given, as the volume required depends on the size of the ducts and the degree of resistance offered by the ampullary outlet. The normal ductal system will hold about 10 cc. of iodopyracet injection, while a dilated ductal tract might require 100 cc. before it is completely filled with the visualizing medium. Occasionally the iodopyracet injection will escape through a gaping ampullary orifice rather than diffuse into the upper hepatic radicles. When this situation exists, the x-ray table should be tilted to a steep incline, with the patient's head pointing downward. If the ducts are reinjected, gravity will compel the iodopyracet injection to flow into the more dependent intrahepatic ducts.

Under what pressures should the iodopyracet be injected into the ductal system? We employ the gravity method. A small glass funnel is connected to the T tube, and the top of the funnel is held about 6 inches (15 cm.) above the level of the antertior abdominal wall. This is filled with an isotonic solution of sodium chloride, which perfuses through the ductal system, displacing air and flushing out sediment which might be lodged in the drainage system. About 20 cc. of iodopyracet injection is then permitted to flow through the ductal

tract, and when the patient complains of a little epigastric discomfort, the roentgenogram is taken. It is important that roentgenograms be taken immediately after the introduction of the iodopyracet injection, as any delay might permit contrast medium to escape into the duodenum, in which event the empty bile ducts would not be visualized.

If the first cholangiogram should demonstrate an obstruction of the common bile duct, then serial roentgenograms are taken at ten minute intervals. In many instances a spastic contraction of the sphincter of Oddi obstructs the ampullary orifice so effectively that none of the opaque medium will be able to pass into the duodenal lumen. If a second roentgenogram is taken ten minutes later, the dyssynergic spasm will have relaxed so that the iodopyracet injection can flow uninterruptedly into the intestinal tract. Differentiation between calculary and muscular obstructions of the ampullary orifice can be made by placing a tablet of nitroglycerin under the patient's tongue and taking a cholangiogram three minutes later. This vasodilating drug causes the sphincteric spasms to disappear, but true organic obstructions are unaffected.

ERRORS OF TECHNIC

The most common oversight in obtaining cholangiograms is the failure to fill all the bile ducts with the contrast solution, which results in only partial visualization of the extrahepatic system. There need be no fear of using too much iodopyracet injection, as this material is nontoxic and is quickly absorbed from the gastrointestinal tract. If the quantity of iodopyracet injection which is introduced into the drainage tubes should exceed the capacity of the ductal system, the excess solution will escape into the duodenum or reflux out through the drainage tube. In either situation no harm has been done.

Care must be exercised to remove all air bubbles from the T tubes before injecting the iodopyracet, as shadows of entrapped "air bubbles" so closely simulate the appearance of intraductal calculi that differentiation might prove bothersome. This can be accomplished by a perfusion of the ductal system with isotonic sodium chloride solution. As iodopyracet injection is miscible with both bile and the sodium chloride solution, the resulting mixture readily diffuses into the entire duct, providing an informative film. When the common duct harbors a "shadow" which is thought to be an air bubble, it has been our practice to make serial cholangiograms with the patient in various positions, such as reclining, head down and erect postures. Air, being lighter than iodopyracet injection, will naturally seek the highest points in the biliary system, and a "shifting shadow" is pathognomonic of entrapped air bubbles. We have found it useful to make subsequent studies on successive days, and if the intraductal defect does not appear

on all roentgenograms one can safely assume that entrapped air was present.

All radiopaque mediums are not satisfactory for cholangiography.[2,3,4] The halogenated oils are so viscid that one may encounter difficulty in forcing them into the smaller bile ducts, so that incomplete filling of the ducts occurs and poor visual patterns are obtained. The radiopaque oils have another disadvantage in that they are not miscible with bile; therefore, the oil and bile "stratify" or "puddle," thus presenting rarefied shadows which might be mistaken for intraductal stones. We have found that such solutions as iodized oil (lipiodol®) and the 70 per cent diodrast® have such a high radiopacity that they may obscure the patterns of small calculi. The use of 35 per cent diodrast® has eliminated all these difficulties.

VALUE OF POSTOPERATIVE CHOLANGIOGRAPHY

Postoperative cholangiography produces an authentic roentgenographic pattern of the extrahepatic biliary system, thereby providing accurate information concerning functional and pathologic changes. Such studies are just as informative for the surgeon dealing with the gallbladder as urograms are for the urologist. Cholangiograms furnish the answers to such perplexing problems as these: Is the persistent external biliary fistula caused by residual calculi, neoplastic obstructions or strictures of inflammatory or traumatic nature? Is the postoperative jaundice due to intraductal obstructions or is it of intrahepatic origin? Were all the intraductal stones removed at the primary operation? Has the obstructive pancreatitis disappeared? Are the drainage tubes patent, and have they been properly placed to obtain the desired decompression? When should the drainage tubes be removed? Such information is essential to the proper management of these complicated problems.

Since 1934 we have made routine postoperative cholangiograms on all patients in whom drainage tubes were inserted into the gallbladder and bile ducts. This series of 750 cases includes our own and similar cases of other surgeons, all of which were studied in the roentgenologic departments of our hopsitals. The types of operations performed consisted of cholecystostomies; cholecystectomies combined with choledochostomies; secondary choledochotomies for stones, strictures and neoplasms; plastic operations on the ducts for traumatic strictures, and anastomotic procedures between the bilary and digestive tracts. The value of cholangiographic studies can best be portrayed by presenting particular problems.

EXTERNAL BILIARY FISTULA

When the sinus tract refuses to heal, after the removal of drains which have been inserted into the gallbladder or the ductal system, the surgeon is confronted with a tantalizing problem. What provokes the persistent discharge? Have elusive intraductal calculi been left behind to obstruct the ampullary outlet? Did the instrumental exploration and probing of the choledochus produce a traumatic edema of the

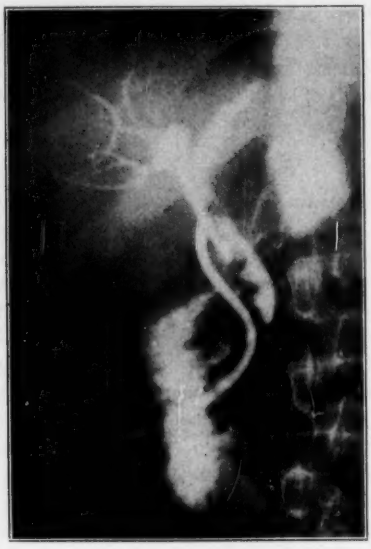

Fig. 1.—Postoperative cholangiogram reveals four residual stones which were overlooked at the primary operation. The upper limb of the T tube has been inserted into the right hepatic duct. Note how the iodopyracet injection flows around the intraductal calculi to enter the duodenum. The tube was removed on the tenth postoperative day and the sinus tract closed spontaneously.

pancreas, causing this succulent organ to compress the outlet of the ampulla? Does the fistula communicate with the gastrointestinal tract, with a subhepatic abscess, or does it drain a subdiaphragmatic collection of stagnant bile? Has the common bile duct been injured by crushing clamps or occluded by a misplaced ligature? Such questions can readily be answered by injecting iodopyracet solution directly into the sinus tract, for the resulting cholangiograms clearly visualize the characterizing deformities of these lesions (fig. 1). The surgeon, therefore, acquires a "blue print" of the problems which he must solve.

OVERLOOKED CHOLEDOCHAL STONES

During the past fourteen years we have performed postoperative cholangiograms on all patients who had stones removed from the common bile duct. This was accomplished by introducing iodopyracet into the T tubes. In this series there were 100 cases, and interestingly the postoperative roentgenograms demonstrated that after choledocholithotomy 12 per cent of the patients still harbored residual stones (fig. 2). It is evident that palpatory and instrumental exploration of the bile ducts affords little assurance that all offending calculi have

Fig. 2.—This cholangiogram clearly outlines the residual stone in the common hepatic duct which is effectively obstructing the left hepatic radicles. The common bile duct is normal, as is evidenced by the free flow of iodopyracet injection into the duodenum. Ten intraductal stones were removed at the primary operation. The sinus tract promptly closed when the drainage tube was removed, in spite of the residual stone in the common hepatic duct.

been removed. Unfortunately many of these patients were our own, and such disheartening experiences provided the incentive for continued investigation in the field of cholangiography.

Many surgeons feel that the spontaneous closure of the external sinus after the removal of the drainage tubes is ample proof that the common duct harbors no obstructive agents. We have collected cholangiographic evidence which persuasively contradicts this concept. In a group of 35 patients proved to have residual stones in their common bile duct a persistent draining sinus did not develop in any instance. In only three instances did the sinus tract remain open for more than

four weeks before closing, for in the majority the tract was sealed off in less than seventy-two hours after removal of the tubes. Progressive studies by roentgenologic visualization conclusively proved that when the stones effected a total obstruction of the distal segment of the bile duct the sinus tract remained open, as it provided a convenient channel for the escape of the stagnant bile. When the cholangitis and pancreatitis had subsided sufficiently so that the stones no longer were able

Fig. 3.—This cholangiogram, made on the eighth postoperative day, shows a marked dilatation of the entire ductal system, caused by a narrowing or constriction of the ampullary zone. At the primary operation the pancreas was found to be enlarged and firm, but the ducts did not contain calculi. This concentric tubular narrowing of the ampullary segment of the bile duct is characteristic of pancreatic compression, and the dilatation of the bile ducts indicates obstruction of long standing.

to occlude the ducts completely, the iodopyracet injection and bile were seen to flow around the calculi and escape into the duodenum; then the fistula would close spontaneously. It is evident that the clincal course of the patient affords little information concerning the completeness of the intraductal operations. Whenever the postoperative cholangiograms revealed that small stones were still lurking in the common bile duct, the patients were appraised of this unfortunate situation, and secondary operations were performed at a later date. Attempts to dissolve stones by chemolyzing perfusions of the common duct have been very disappointing to us.

OBSTRUCTIONS OF THE CHOLEDOCHUS BY THE PANCREAS

Acute cholecystitis and choledocholithiasis are often complicated by acute or subacute pancreatitis because the infective process becomes disseminated or the irritating bile refluxes into the larger pancreatic ducts. The swollen pancreas exerts a concentric compression on the terminal portion of the choledochus, obstructing its ampullary orifice and often initiating a severe cholemia (fig. 3). Effective therapy requires that the obstructed ductal system must be drained by means of indwelling tubes. How long shall the decompression be employed? This question can be definitely answered by means of cholangiograms. When the roentgenograms demonstrate that the iodopyracet, which has been injected into the drainage tubes, is able to pass uninterruptedly through the ampullary orifice into the duodenum, then it is safe to assume that the pancreatic obstruction has disappeared, and the drainage tubes can be removed. In a group of 30 patients the pancreatitis had subsided by the eighth postoperative day, because the cholangiograms visualized a patent ampullary outlet. All decompressive catheters were removed. This obviated the practice of prolonged ductal drainage, thus shortening the period of hospitalization and eliminating the discomfort associated with wearing a drainage catheter.

POSITION OF DRAINAGE TUBES

Drainage tubes are placed in the gallbladder and the bile ducts for but one purpose, that of decompressing an obstructed biliary tract. Often, as shown by cholangiographic studies, these drainage tubes fail to accomplish the purpose for which they were inserted. For example, when a T tube is employed, the upper limb of the tube should rest in the common hepatic duct, while the lower end extends into the choledochus. We have found, however, that often the upper end of the T tube had been threaded into either the left or the right hepatic ducts. If the right hepatic duct was catheterized, this provided excellent drainage for the right lobe of the liver but the solid wall of the tube obstructed the stoma of the left hepatic duct, thereby initiating retention jaundice (fig. 5). Similar cases were studied in which the left hepatic duct was intubated while the drainage tube obstructed the entire right lobe of the liver. Such mistakes result from variations in the length of the common hepatic bile ducts. In some patients this duct may measure only 1 cm. in length, and in the next case it may be 5 or 6 cm. long. Cholangiograms depict such anatomic variations.

Recently we encountered a patient in whom the operator had placed the upper limb of the T tube in the common hepatic duct and threaded the distal limb into a dilated, aberrant cystic duct, which crossed over the common hepatic duct before uniting to form the choledochus. It

was not until the postoperative cholangiograms demonstrated that the misplaced T tube was obstructing the common bile duct that a suitable explanation for the increasing cholemia could be found (fig. 4). Subsequent studies indicated that the abnormally placed cystic duct and choledochus both contained large stones which had been overlooked at the primary operation.

Fig. 4.—This cholangiogram was made on the fourteenth postoperative day. Observe how the cystic duct first crosses over and then passes down along the mesial margin of the common hepatic duct before the two unite to form the choledochus. The upper limb of the T tube was inserted into the common hepatic duct, and the lower end was inadvertently placed in the aberrant cystic duct. Three stones obstruct the common hepatic duct, the cystic duct and the upper end of the choledochus, while the terminal segment of the common bile duct appeared normal. These findings were verified at the second operation.

Postoperative cholangiograms have likewise demonstrated that drainage catheters which have not been securely anchored will occasionally slip out of the bile ducts and dangle free within the peritoneal cavity. Premature slipping of the drainage tubes permits the bile to escape through the choledochal sinus into the abdominal cavity, thus causing a cholemic intoxication. When such complications are encountered, the operative incision should be reopened so that the toxic peritoneal fluids can escape. Routine postoperative cholangiograms, therefore, not only

visualize the position of the drainage tubes but afford an effective method of determining their functional value (fig. 5).

SUMMARY

Postoperative cholangiography is the science of visualizing the extrahepatic biliary tract by means of contrast roentgenography. This is accomplished by introducing a suitable radiopaque substance, such as iodopyracet injection (diodrast®) into drainage tubes which have been placed in the gallbladder or the bile ducts. This study comprises an analysis of 750 postoperative cholangiograms. These cholangiograms provide an accurate method of visualizing the obstructions which are responsible for external biliary fistulas and of determining the size, number and position of "overlooked" choledochal stones. One hundred patients who had undergone choledocholithotomies were studied, and 12 per cent were found to have "elusive stones" remaining in the common duct after the primary operation. Postoperative cholangiograms are invaluable in determining when the obstructive pancreatitis has subsided, thus indicating the proper time for removal of drainage tubes. They afford an accurate method of differentiation between organic biliary obstructions and bilary dyssynergias. Misplacement of drainage tubes can be readily determined by this method. The technic, indications and errors of postoperative cholangiography are discussed.

Fig. 5.—The T tube has been inserted so that the upper limb intubates the right hepatic duct, while it obstructs the left hepatic radicles. The enormous dilatation of the intrahepatic ducts of the left lobe of liver indicates a rather complete obstruction. The postoperative jaundice immediately disappeared as soon as the T tube was removed.

EXPERIMENTAL PRODUCTION OF AN EXTRACARDIAC SHUNT AROUND THE MITRAL VALVE

Preliminary Report

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IN CERTAIN cases of heart disease of rheumatic origin there is stenosis of the mitral valve which is accompanied with only mild involvement of the myocardium. In such instances the disturbed circulatory physiology is traceable almost wholly to obstruction at the valve. Circulatory embarrassments are principally of two kinds. First, there is insufficient filling of the left ventricle during diastole, resulting in a failure of the heart to supply adequate amounts of blood to the periphery, particularly under conditions of increased exercise which raise the demands for an augmented flow to the locomotor system. Second, the damming up of blood behind the stenotic valve causes engorgement of the pulmonary bed which can lead to pulmonary edema, respiratory distress, hemoptysis, limitation of physical activity and even fatality. Such pulmonary congestion is particularly aggravated during periods of exercise when the right ventricle increases its output but the flow of blood is impeded by the bottleneck at the constricted mitral valve.

The treatment of heart disease of this type has been almost entirely by medical means. Palliative measures include digitalization to slow the heart and allow better filling of the left ventricle during diastole, rest for lowering the demands on the circulation and diuresis to reduce the volume of the circulating medium.

Several proposals have been made for the relief of obstruction which occurs at stenosed valves. The most comprehensive review of this subject is that of Cutler, Levine and Beck,[1] published in 1924. Their article traces the history of valvulotomy from the publication of Sir

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This investigation was supported (in part) by a research grant from the National Heart Institute, United States Public Health Service.

1. Cutler, E. C.; Levine, S. A., and Beck, C. E.: The Surgical Treatment of Mitral Stenosis: Experimental and Clinical Studies, Arch. Surg. **9**:689 (Nov.) 1924.

Lauder Brunton's [2] papers in 1902 up to the time of their own work. The plan which they proposed and tried out was to enlarge the mitral orifice by cutting out a piece of the thickened and contracted valve, but this unfortunately produced serious mitral regurgitation. Their results were disappointing; of 5 patients operated on, 4 died within a few days. Harken, Ellis, Ware and Norman [3] as well as Bailey and Glover have reopened the subject of directly enlarging a contracted mitral orifice in human beings by removing a piece of the same or by commissurotomy. These operations have shown more promising results, now that efforts are made to keep regurgitation at a minimum.

To relieve congestion in the left auricle and in the pulmonary circuit, it has been suggested that an interauricular septal defect be created, with the realization that human beings with a Lutembacher syndrome tend to live longer than do those with mitral stenosis alone. Bland and Sweet [4] have attempted, with considerable success, to relieve the pulmonary hypertension by anastomosing the dorsal segment branch of the right inferior pulmonary vein to the azygos vein, thereby reducing somewhat the excessive pressure within the left auricle.

In 1914 Tuffier and Carrel [5] were able to by-pass the pulmonary valve in dogs to some degree by cutting the valve ring and applying a patch over the defect to enlarge it. More recently Hurwitt [6] studied the possibility of implanting a curved plastic tube around the pulmonary valve, making a pathway from the right ventricle into the side of the pulmonary artery. This work was done on cats, with survival of some of the animals.

In 1913 Jeger [7] suggested that the mitral valve be by-passed by means of a vascular shunt, made directly from the pulmonary veins to the left ventricle, a segment of vein being employed for such a channel. Furthermore, he suggested that a portion of vein be used which had intact valves, hoping to prevent reflux from the ventricle into the pulmonary circuit. He did not report trial of this method.

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2. Brunton, L.: Collected Papers on Circulation and Respiration, London, Macmillan & Company, 1914.

3. Harken, D. E.; Ellis, L. B.; Ware, P. F., and Norman, L. R.: The Surgical Treatment of Mitral Stenosis: I. Valvuloplasty, New England J. Med. **239**:80, 1948.

4. Bland, E. F., and Sweet, R. H.: A Venous Shunt for Advanced Mitral Stenosis, J. A. M. A. **140**:1259 (Aug. 13) 1949.

5. Tuffier, T., and Carrel, A.: Patching and Section of the Pulmonary Orifice of the Heart, J. Exper. Med. **20**:3, 1914.

6. Hurwitt, E. S.: An Experimental Approach to the Problem of Increasing the Blood Supply to the Lungs: Preliminary Observations on the Use of Plastics, Surg., Gynec. & Obst. **87**:313, 1948.

7. Jeger, E.: Die Chirurgie der Blutgefasse und des Herzens, Berlin, J. Hirschwald, 1913.

It appeared to us theoretically possible to build some sort of an extracardiac shunt, constructed in such a way that blood could flow directly from the left auricular appendage into the left ventricle and thereby circumvent an obstructed (stenotic) mitral valve. Such a by-pass should be durable and should contain a valve which can be relied on to prevent regurgitation.

Within recent years, materials and methods have become available which now make it worthwhile to consider the construction of extracardiac shunts. We [8] have developed methods for the preservation of segments of arteries in such a way that they can be kept for as long as thirty to forty days before being successfully grafted into the arterial system of another individual of the same species. Another recent

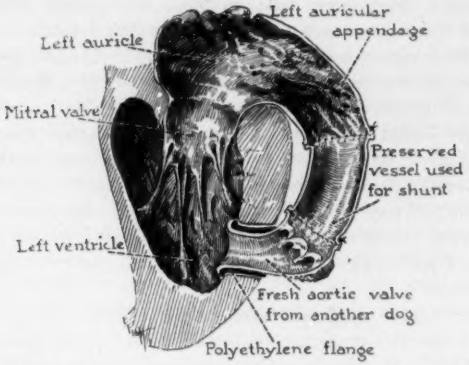

Fig. 1.—Schematic drawing, coronal section through heart, to show plan of attempt to establish an extracardiac shunt between the left auricle and the left ventricle.

development has been the knowledge gained concerning the toleration of the animal or human body for various plastics. Hufnagel's [9] report on the use of methyl methacrylate tubes for intubation of the aorta, Ingraham, Alexander and Matson's [10] study on the use of polyethylene

8. Gross, R. E.; Bill, A. H., Jr., and Peirce, E. C., II.: Methods for Preservation and Transplantation of Arterial Grafts: Observations on Arterial Grafts in Dogs; Report of Transplantation of Preserved Arterial Grafts in Nine Human Cases, Surg., Gynec. & Obst. **88**:689, 1949.

9. Hufnagel, C. A.: Permanent Intubation of the Thoracic Aorta, Arch. Surg. **54**:382 (April) 1947.

10. Ingraham, F. D.; Alexander, E., Jr., and Matson, D. D.: Medical Progress: Synthetic Plastic Materials in Surgery, New England J. Med. **236**:326 and 402, 1947.

in the body and Hurwitt's [6] work in by-passing the pulmonary valve with polyethylene tubes all show that it is possible to use certain plastic materials as an adjunct to surgery.

With the possibility in mind of using grafted vessels and also certain plastic materials, a plan for by-passing the mitral valve was tested in a few dogs.[11] The shortest and most accessible route seemed to be from the left auricular appendage to the left ventricle. As the pathway for this extracardiac shunt, we employed a segment of aorta which had been obtained previously from another dog and which had been preserved for some days in the cold (not frozen) in a modified Tyrode's solution.[8] To prevent regurgitation in the system an aortic valve, freshly secured from another donor dog, was inserted into the pathway. At the point where the vessel was to pierce the left ventricular wall,

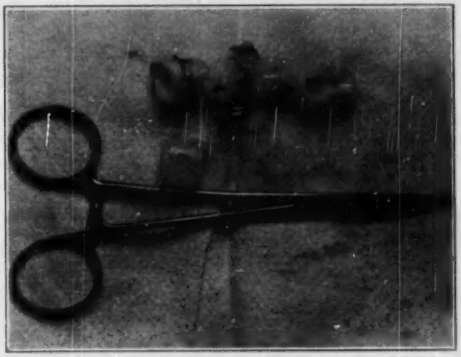

Fig. 2.—The vascular shunt ready for insertion. It has been made from a piece of preserved aorta and from an aortic valve (from other donor dogs). The valvular end (toward the left) has been turned back over a polyethylene flange. (An extra flange lies adjacent to the instrument.)

its mouth was to be kept open by encircling it with a small sleeve or tube of polyethylene. A diagram of the proposal may be seen in figure 1.

A preliminary experiment was carried out, with no thought of preserving the animal beyond an acute phase. A shunt system was constructed (fig. 2) by joining a segment of preserved aorta and a freshly secured aortic valve by an end to end anastomosis using an everting mattress suture. The vessel was then drawn through a

11. Gross, R. E.; Peirce, E. C., II.; Rheinlander, H. F., and Bill, A. H., Jr.: Establishment of Extra-Cardiac Shunts for Treatment of Stenosed Cardiac Valves, Bull. Am. Coll. Surgeons **34**:26, 1949.

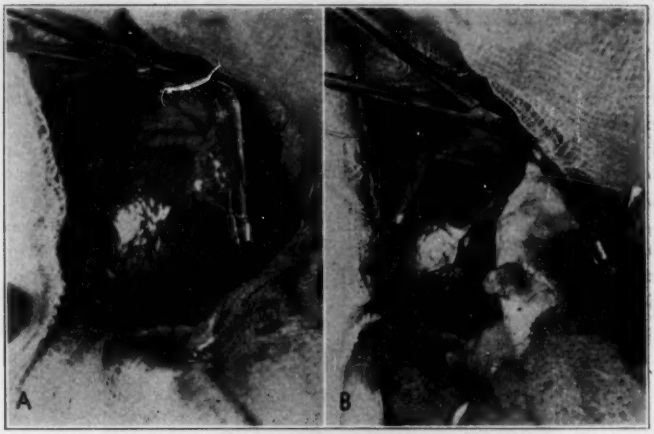

Fig. 3.—*A*, heart of recipient dog exposed. The auricular appendage grasped by a right angle clamp. *B*, tip of the auricular appendage has been cut off. The shunt system has been anastomosed to the auricular appendage.

Fig. 4.—*A*, stay sutures in place in myocardium of the left ventricle. *B*, myocardium grasped by two vulsella clamps. These instruments are held together by the assistant while an incision is made in the myocardium and are relaxed while the free end of the shunt is thrust into the myocardial opening.

flanged polyethylene tube, and its protruding cuff, about 3 mm. long, was folded back over the flange and secured by sutures of silk. The heart of the recipient dog was then exposed, and the auricular appendage was grasped with a rubber-shod right angle clamp (fig. 3*A*) and its tip excised. The proximal end of the shunt system was now anastomosed to the auricular appendage by an everting, continuous mattress stitch of fine silk (fig. 3*B*). A point was now selected on the left ventricle which was about two thirds of the way down from the auricle to the apex of the heart (fig. 4*A*); this area was relatively avascular. The myocardium on either side of this point was grasped with a double-pronged Schroeder vulsella tenaculum (fig. 4*B*) and an incision made into the left ventricle. Hemorrhage was kept at a minimum by having the assistant hold the tenacula in such a way that they compressed the sides of the myocardial slit. With the free end of the shunt then poised above the area, pressures on the tenacula were released so that the myocardial slit opened and could receive the shunt vessel which was plunged into it. The end of the shunt (with its plastic casing) was introduced until it was firmly seated with the flange just inside the endocardium. Sutures were now placed to close the ends of the incision and a few stitches were taken from the adventitia of the shunt to the edges of the surrounding myocardium. The animal tolerated this implantation of the shunt (fig. 5) well. Shortly after the extracardiac circuit had been completed, a slit was made in the posterior part of the left auricle and the operator's finger was inserted through the auricle into the mitral valve; this largely occluded the valve orifice and forced most of the circulating blood to go through the shunt system. This situation was tolerated by the animal without embarrassment for ten minutes, after which the finger was withdrawn and the animal was killed.

Nine further operations were performed for the construction of similar shunts, with the hope of keeping the animals for protracted periods. Of these animals, 3 were lost on the table, 1 from coronary air embolism and 2 from ventricular fibrillation. One animal died of shock twenty-four hours after operation. Four died one to eight days after operation from hemorrhage resulting from a breakdown of the anastomosis between the shunt and the myocardium. Until the breakdown of the anastomosis, these animals were generally active and showed no recognizable cardiovascular embarrassment. One animal survived for four months and was then killed; he was healthy and frisky throughout this entire period.

Autopsy of this dog which survived for four months showed the shunt to be patent, though there was considerable fibrosis and narrowing of the anastomosis between the shunt and the auricular appendage. The transplanted valve leaflets were markedly shriveled and fibrotic; the degeneration had robbed the valve of any competence.

While all these experiments have seemingly resulted in failure, certain facts have been gathered and new lines of profitable research have been suggested. 1. On first thought, the construction of shunts around stenosed valves would seem to present insuperable technical difficulties, but our brief excursion into this field inclines us to believe that possibly such pathways can be successfully established. 2. We are convinced that a ventricular wall can be penetrated and that a vessel can be attached thereto. It is obvious, however, that the use of any

Fig. 5.—The completed shunt, carrying blood.

rigid material for a cuff at the site of the anastomosis is undesirable since it will probably lead to regional ulceration and subsequent fatal hemorrhage. 3. The major portion of such an extracardiac shunt can probably be constructed from preserved (homologous) vessel grafts. 4. It is impossible to incorporate into the shunt system any valves (grafted from another animal of the same species), because of the rapid degeneration which appears in the leaflets and leads to regurgitation. Hence, if any such extracardiac shunt is to have permanent value, its success must rest on the development of some artificial valve mechanism which could be inserted into the system.

SUMMARY

Experiments have been started in the attempt to devise methods for circumventing a stenosed valve. Description is made of attempts to construct a pathway from the left auricle to the left ventricle, by-passing the mitral valve, in the hope of constructing such a channel from a preserved segment of aorta of another animal and fitting it with a valve likewise taken from another dog. Our early impressions lead us to think that it might be technically feasible to build such a channel from grafted vessels, that this can probably be joined to a ventricular wall (though this must be done without a rigid cuff such as we employed) but that it is wholly unsatisfactory to use grafted valves to prevent regurgitation in such a system. Future progress in the construction of extracardiac shunts depends largely on the possibility of developing a mechanical valve mechanism which could be inserted in such a pathway.

NONSPECIFIC MESENTERIC ADENITIS

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SINCE the existence of a nonspecific form of mesenteric adenitis has been recognized for many years, much has been written about it. The significance of this condition rests primarily in the role which it assumes in the diagnosis of an acute condition within the abdomen, particularly in children. Inasmuch as it is one of the most frequent conditions encountered by the general or pediatric surgeon, this study was undertaken in an attempt to correlate the existing knowledge of this entity, to place the pathogenesis on a somewhat firmer basis, to present the results of an investigation of a possible virus etiology and to review the condition as it occurred clinically over a five year period at the Children's Hospital, Washington, D. C.

HISTORICAL REVIEW

Enlargement of mesenteric lymph nodes has been recognized as contributing to the difficulties of diagnosis of abdominal conditions from the time of Hodgkin.[1] The first description of this condition is attributed to Sydenham, in 1723.[2] The pathologic changes were described by Werner and Feller in 1784, and the numerical distribution of the nodes was studied by Cruikshank in 1786. Mascagni in 1787 and Virchow almost seventy-five years later described lesions of these nodes. These early reports were from autopsy material, unsupported by laboratory data.[3] Most authors during this time were influenced by the German school and accepted the view that such adenopathy was invariably of tuberculous origin.[4] Machtle [5] in 1909 could find only 14 reported cases, all considered to have a tuberculous origin.

From the Department of Surgery, Georgetown University Medical Center.

1. Foster, A. K.: Disease of the Mesenteric Lymph Nodes, Arch. Surg. **36**:28-52 (Jan.) 1938.

2. Ireland, J.: Etiologic Factors of Mesenteric Lymphadenitis, Arch. Surg. **36**:292-302 (Feb.) 1938.

3. Wilensky, A. O.: General Abdominal Lymphadenopathy, Arch. Surg. **42**:71-125 (Jan.) 1941.

4. (*a*) Bertien and Worms, cited by Ireland.[2] (*b*) Coleman, E. P.: The Diagnosis of Acute Mesenteric Lymphadenitis, Illinois M. J. **68**:408-413, 1935. (*c*) Mead, C. H.: Mesenteric Lymphadenitis Simulating Acute Appendicitis, Arch. Surg. **30**:492-527 (March) 1935.

5. Machtle, cited by Wilensky, A. D.: Surg., Gynec. & Obst. **72**:1060-1069, 1941.

With the advent of modern surgery, various forms of mesenteric adenopathy were recorded, but because of inadequate laboratory studies they were assumed to be tuberculous. In 1920 Wilensky [6] reported 3 cases of nontuberculous mesenteric adenitis, and the following year Brenneman [7] called attention to the occurrence of this condition during the course of infection of the upper respiratory tract in children in whom abdominal complaints developed. Heusser [8] in 1923 substantiated the contention that a nontuberculous form existed. He examined, both bacteriologically and histologically, nodes removed at operation and failed to demonstrate the tubercle bacillus or any other organism. In the same year Freeman [9] expressed the opinion that acute mesenteric adenitis was an abdominal entity and stressed the need for considering it in the differential diagnosis of appendicitis. Wilensky and Hahn [10] in 1926 described the anatomy of these nodes and postulated a mechanism for the production of the nonspecific form of adenitis. Since that time much literature on this subject has accumulated.[11] However, certain features of the condition remain relatively obscure, particularly the pathogenesis, etiology and differential diagnosis. Though a real clinical entity, it remains a disease of theories.

ANATOMY OF THE MESENTERIC LYMPH NODES

A résumé of the anatomy of the lymphatic vessels involved in this condition should facilitate a better understanding of the mechanism of its development and preclude consideration of theories based on false anatomic concepts.

This lymphatic system originates in the primary lacteal vessels of the intestinal villi. In the submucosa, particularly in the distal portion of the ileum, are located masses of lymphoid tissue, known as Peyer's patches. These structures are intimately related, and the patches function in a manner analogous to lymph nodes elsewhere. Efferent branches from these accumulations of lymphoid tissue mingle in a lymphatic vessel network in the intestinal wall, penetrating it near the entrance of the intestinal blood vessels. The direction of flow of the lymphatic current is away from the intestinal wall, toward the mesenteric nodes.[10]

6. Schrager, V. L.: Clinical Aspects of Mesenteric Adenitis, Am. J. Surg. **351**:539-545, 1937.

7. Brenneman, J.: Practice of Pediatrics, Hagerstown, Md., W. F. Prior Company, 1936, vol. 2, chap. 39.

8. Heusser, H., cited by Wilensky, A. O., and Hahn, L. J.: Ann. Surg. **83**: 812-826, 1926.

9. Freeman, L.: Surgical Significance of Mesenteric Adenitis, Surg., Gynec. & Obst. **37**:149-151, 1923.

10. Wilensky, A. O., and Hahn, L. J.: Mesenteric Lymphadenitis, Ann. Surg. **83**:812-826, 1926.

11. (*a*) Emmett, J. M.; Fleiss, M., and Yarkoff, F. H.: Review of Literature on Mesenteric Adenitis, Virginia M. Monthly **66**:105-108, 1939. (*b*) Lawen, E.: Appendicitis and Regional Lymphatic Glands, Zentralbl. f. Chir. **65**:2018, 1938.

The mesenteric nodes are disposed in three definite locations: (1) at the last anastomotic branching of the mesenteric arteries before they enter the intestine; (2) in the region of the next larger anastomosing branches of the mesenteric blood vessels, and (3) at the root of the mesentery near the origin of the main mesenteric arteries. The nodes are more numerous in the right half of the abdomen, and they occupy a considerable amount of space in the mesentery. They become progressively larger and more numerous near the root of the mesentery.

The flow of lymph through these nodes is as a rule directly from one to the next proximal one.[12] In some instances it would seem that the juxtaintestinal nodes are by-passed, with a resultant enlargement of the middle group. While such a mechanism is not clear in some cases, in others a developmental change or previous inflammatory involvement may explain this by-passing of one group of nodes. Retrograde lymph flow probably occurs, but only if the pathway to its progress is completely obstructed.

It should be remembered that the quantity of lymphoid tissue fluctuates throughout life. It is present in proportionately greater amounts in children. Mead [4c] carried out a detailed study of the mesenteric nodes in infants and children. He concluded that the number and size of the nodes varied greatly. Careful observation revealed that the size and weight of the nodes were directly proportional. On the basis of this work, it should be pointed out that in children a visible, palpable node is not necessarily abnormal. In children there is normally an abundant lymph drainage from the intestinal tract, and this is most noticeable in the distal portion of the ileum. A parallel has been drawn between the lymphatic vessels of the intestines and the cervical nodes. It has been established that the mesenteric nodes function in a manner analogous to the cervical nodes in providing a defense mechanism against bacteria and other substances.

Certain physiologic features peculiar to the distal portion of the ileum have some bearing on the function of the mesenteric nodes. The absorptive function of the intestinal tract combined with the constant presence of bacteria in its lumen offers a potential focus of invasion. There is considerable stasis of the intestinal content in the terminal region of the ileum, a factor favoring "absorption" of bacteria or other noxious agents, and this occurs in the absence of demonstrable mucosal lesions. Growth of bacteria in this region is enhanced by the change from an acid to an alkaline reaction, which occurs normally.

Some mention should be made of the mechanism of the production of pain in mesenteric adenitis, which is possibly a twofold one. Irritation

12. McFadden, G. D. F.: Mesenteric Lymphadenitis and Its Clinical Manifestations, Brit. M. J. **2**:1174-1177, 1927.

of adjacent sympathetic nerves may induce remote effects, e. g., periumbilical pain, which is common.[11b] Ileal spasm, consequent on a disorder affecting the ileum, may induce colic. Braithwaite,[13] in a discussion of the "ileo-gastric syndrome," described a pathologic situation evolving from noxious stimuli in the ileum and producing signs and symptoms in the gastric region, e. g., pain, nausea and vomiting. These features are common in mesenteric adenitis.

ETIOLOGY

Since the demonstration of a nonspecific form of mesenteric adenitis, repeated efforts to establish its etiology have been made.[2] Thus far, no conclusive results have been obtained.

For the most part, the reported studies have been statistically insignificant and the results have been inconclusive. Most workers report that cultures of the mesenteric nodes are sterile.[14] Others report occasional positive cultures.[15] The fact that a positive culture is obtained from a single mesenteric node does not immediately incriminate the isolated organism. Such is particularly true in the case of Escherichia coli and other organisms that are normally found in the intestinal flora. Organisms such as the hemolytic streptococci may be considered of pathologic significance, but their precise role is difficult to evaluate because of the inconstancy of their occurrence. Collins[16] reported a series in which the throat culture in 37 of 39 patients showed the presence of Streptococcus hemolyticus, and in 24 cases mesenteric nodes yielded positive cultures, the organisms including Str. hemolyticus, Esch. coli, Escherichia acidi lactici and Eberthella enterica. Another report[17] revealed a similar high incidence of Str. hemolyticus in throat cultures, but in only 1 of these cases was this organism recovered from an excised node.

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13. Braithwaite, L. R.: The Ileo-Gastric Syndrome, Brit. J. Surg. **30**:15-22, 1942.

14. (*a*) Sobel, I. P., and Stilten, De W.: Non-Specific Mesenteric Adenitis, J. Pediat. **17**:305-314, 1940. (*b*) White, C. S., and Collins, J. L.: Acute Mesenteric Adenitis, J. A. M. A. **109**:1023-1025 (Sept. 26) 1936. (*c*) Tilley, J. A.: Acute Nonspecific Mesenteric Lymphadenitis, Am. J. Surg. **57**:472-476, 1942. (*d*) Rosenburg, S.: Nonspecific Mesenteric Lymphadenitis, Arch. Surg. **35**:1031-1044 (Dec.) 1937.

15. (*a*) Adams, W. E., and Olney, M. B.: Mesenteric Lymphadenitis and the Acute Abdomen, Ann. Surg. **107**:359-370, 1938. (*b*) Postlethwait, D. W.; Self, W. O., and Batchelor, R. P.: Nonspecific Mesenteric Lymphadenitis, Am. J. Surg. **57**:304-315, 1942. (*c*) King, W. E.: Acute Nonspecific Mesenteric Adenitis, Am. J. Surg. **64**:92-94, 1944. (*d*) Urech, E.: Mesenteric Adenitis and False Appendicitis, Schweiz. med. Wchnschr. **70**:1152, 1940.

16. Collins, D. C.: Mesenteric Lymphadenitis in Adolescents Simulating Appendicitis, Canad. M. A. J. **34**:402-405, 1936.

17. Goldberg, S. L., and Nathanson, I. T.: Acute Mesenteric Lymphadenitis, Am. J. Surg. **25**:35-40, 1934.

The location of the nodes yielding positive cultures is cited by Postlethwait and others [15b] as of possible significance. Because of the filtering action of the lymph nodes, selection of a node in the primary group, i. e., nearest the intestine, in preference to one in a secondary group may mean the difference between a positive and a negative culture

In the absence of a demonstrable bacterial source of the infection, some have suggested a toxic origin.[18] However, no positive evidence for such an etiology has been offered.

The possibility of a virus etiology has also been considered. White,[19] in 1936, in discussing this condition, offered the suggestion that a virus might be of etiologic importance. McKinley,[20] in investigating this possibility, found no intracellular inclusion bodies in any excised nodes. He suggested inoculation of ferrets with emulsions prepared from these nodes as a possible means of demonstrating a virus. Because of this investigator's untimely death, the work was never carried out. Wise,[21] reporting a small series in which a single node was removed and studied, stated that no filterable virus could be demonstrated.

In the course of this investigation, virus cultural studies on excised nodes from 5 cases were carried out at the National Institute of Health, Bethesda, Md. After suitable emulsification of the specimens, 4 mice and 1 monkey were inoculated. In all cases negative results for virus isolation were reported.

PATHOGENESIS

In like manner, the pathologic physiology of mesenteric adenitis has been the subject of more theorization than demonstration of fact.

The appendix has received most attention as the source of infection of the mesenteric nodes, Kerley and others [22] having referred to the appendix as the "abdominal tonsil." However, the anatomy of the nodes concerned and the direction of the lymph flow tend to deny this theory. Further, it is well known that most cases of acute appendicitis are unaccompanied with mesenteric lymphadenopathy. Most investigators are generally agreed that the appendix and the mesenteric lymph nodes do not have a cause and effect relationship to each other with respect to acute inflammatory processes. The abundant lymphoid tissue in the appendix, the terminal portion of the ileum and the mesenteric nodes favors the possibility that a generalized disease of the lymphatic system may simultaneously involve any or all of these sites, including the appendix.

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18. Wilensky.[8] Postlethwait.[15b]

19. White, C. S.: Acute Mesenteric Adenitis: A Filterable Virus Disease?, South. Med. & Surg. **98**:523-526, 1936.

20. McKinley, E. B., cited by White.[19]

21. Wise, W. D.: Mesenteric Lymphadenitis, Ann. Surg. **109**:827, 1939.

22. Kerley, C. G. P., cited by Brenneman, J.: J. A. M. A. **89**:2183-2186 (Dec.) 1927.

The frequent occurrence of an infection of the upper respiratory tract prior to the onset of abdominal symptoms has led many to indict the respiratory infection as a pathogenic factor,[23] either by reason of direct extension of bacterial infection through the intestinal wall or through dissemination of toxins from the bacteria. Brenneman [24] many years ago called attention to the importance of abdominal pain occurring with or shortly after infection of the throat.

No satisfactory evidence for a hematogenous origin of the infection has been offered, and because of the relative benignity of this disease and its rather localized site of involvement,[1] such a source seems unlikely. Thus a lymphogenous and/or an enterogenous mode of infection appears as the more plausible possibility.

Mesenteric lymphadenopathy is known to occur in association with specific diseases, notably, tuberculosis, typhoid, bacillary dysentery and certain of the exanthematous diseases. Such a specific etiologic factor was evident in the following case:

J. B., a white boy aged 8, was admitted to the hospital with a history of nausea, vomiting and periumbilical pain for twelve hours. The pain had localized in the right lower region of the abdomen shortly before admission. The admission temperature was 101 F. Moderately severe abdominal tenderness localized in the right lower quadrant, with distinct rigidity, was found. A white blood cell count of 13,900 with 75 per cent polymorphonuclear forms was reported. Urinalysis revealed moderate albuminuria, some casts and a few red cells.

At operation the appendix showed minimal inflammatory changes. In the mesentery of the ileocecum a firm 5 cm. mass, covered with fibrin, was visualized, dissected free and removed.

Microscopically, the appendix revealed early acute catarrhal inflammation with hyperplasia of the lymphoid elements. Sections from the mesenteric mass demonstrated it to be a lymph node with marked fibrosis and accentuation of the lymph follicles. Some areas showed reticuloendotheliosis. Areas of caseation and occasional giant cells were observed (fig. 1). Polymorphonuclear leukocytes were virtually absent, but there were many round cells, epithelioid and reticuloendothelial cells. Although attempts to demonstrate the tubercle bacillus in stained sections were unsuccessful, a presumptive pathologic diagnosis of tuberculous mesenteric adenitis was made. In view of the patient's birth and residence in Mexico for six years, it was the opinion of his father, a Pan-American public health official, that the condition represented a form of bovine tuberculosis.

Postoperatively the patient had an uneventful course and was discharged in seven days.

In bacillary dysentery, a concomitant inflammation of the distal portion of the ileum has been noted.[25] These phenomena are considered

23. Coleman,[4b] Schrager.[6]

24. Brenneman, J.: The Abdominal Pain of Throat Infections in Children, and Appendicitis, J. A. M. A. **89**:2183-2186 (Dec. 24) 1927.

25. Felsen, J.: Nonspecific Mesenteric Adenitis, Am. J. Dis. Child. **50**:661-672 (Sept.) 1935.

a "response to injury," with the lymphatic system functioning as a protective mechanism against further spread of the infection. In these specific conditions, the source of the infective agent is enterogenous, with a lymphoid reaction similar to that seen in the nonspecific form of mesenteric adenitis. In the absence of a proved bacterial source of infection, it can be theorized that a bacterial toxin or other noxious agent, may initiate its effects in the distal portion of the ileum, where

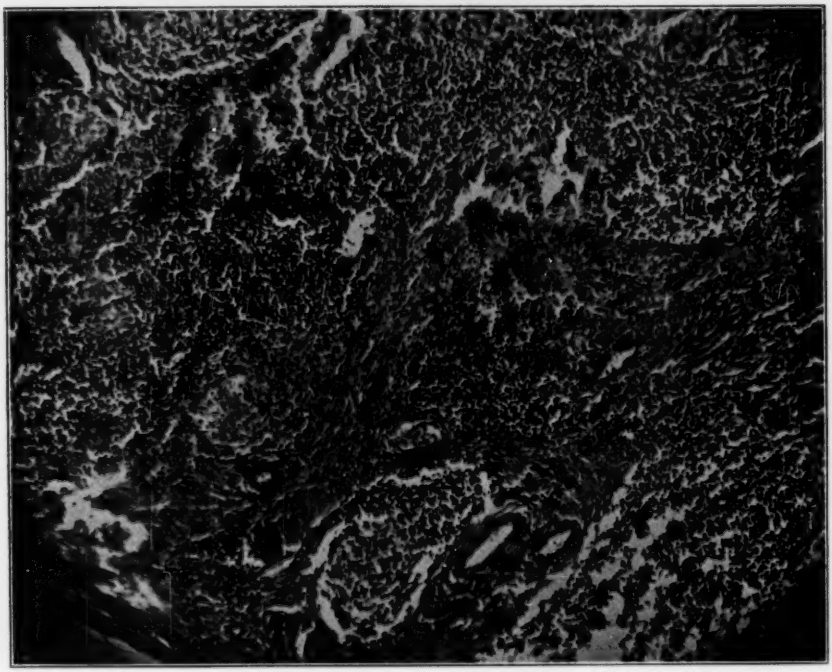

Fig. 1.—Tuberculous mesenteric lymph node.

physiologic conditions are favorable and eventuate in involvement of the lymphatic elements which are so intimately related.[26]

26. (*a*) Cornioley, C.: Acute, Non-Specific Adenitis of the Mesentery, Arch. d. mal. de l'app. digest. **17**:151-164, 1927. (*b*) Klein, W.: Nonspecific Mesenteric Adenitis, Arch. Surg. **36**:571-585 (April) 1938. (*c*) Wilensky, A. O.: "Acute and Chronic Intra-Abdominal Lymphadenopathy," Surg., Gynec. & Obst. **72**:1060-1069, 1941. (*d*) Segar, L. H., and Rosenak, B. D.: Non-Tuberculous Mesenteric Lymphadenitis in Childhood, Am. J. Digest. Dis. **2**:356-360, 1935. (*e*) Postlethwait.[15b] (*f*) King.[15c]

Freeman[9] believed that the source of infection was within the intestine and postulated that the infective agent gains entrance by absorption from normal or possibly "catarrhal" mucosa. The passage of bacteria and other material through the intestinal wall via the lymphatic vessels in the absence of a mucosal lesion has been demonstrated[26d] and the mesenteric nodes deter these materials as they pursue an efferent course from the intestine. Wilensky[26c] summarized his views by stating that "the absorption function of the intestinal tract combined with the constant presence of bacteria in the intestinal lumen creates a situation in which the passage of bacteria from the bowel interior into the associated lymphatic vessels and glands must be considered an almost 'normal' and 'physiological phenomenon.'"

A composite of these sundry views suggests this pathogenic mechanism: (1) intestinal "infection" by some organism; (2) ulceration of the mucous membrane (even of slight degree); (3) mesenteric lymphangitis, followed by (4) enlargement of the nodes and the production of an inflammatory process of varying severity.

The observation of edema and/or inflammation of the distal portion of the ileum in the presence of mesenteric adenitis is not infrequent. The possible relationship of this feature to the adenopathy is considered more fully in the discussion of the pathologic process.

PATHOLOGIC PROCESS

The gross and microscopic picture seen in the lymph nodes in this nonspecific form of mesenteric adenitis is constant and need not be discussed at length.

When observed in situ, the nodes are conspicuously enlarged and smooth and vary from pink to deep red. The overlying peritoneum may be reddened and injected. Characteristically, a moderate amount of clear fluid is present in the peritoneal cavity. This fluid is invariably sterile. On palpation the nodes are movable and firm. The largest are often seen near the root of the mesentery. Pribram[27] has called attention to the occurrence of mesenteric lymphangitis, the lymph vessels appearing as strings of varying thickness and being palpable as cordlike structures. In his opinion, this lymphangitis plays an important role in the condition, and he suggested that cicatricial changes in these channels might account for recurrences.

When the overlying serosa is incised, the node will often bulge into the opening and is removed without great difficulty. The cut surface of the excised node is usually homogeneous, varying from yellowish pink to red and from soft to moderately firm.

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27. Pribram, B. O.: Umbilical Colic: Lymphangitic Form of Appendicitis and Mesenteric Lymphangitis, J. A. M. A. **105**:473 (Aug. 10) 1935.

Microscopically, the picture is not as impressive as the gross appearance of the nodes might lead one to expect. The capsule of the node reveals some thickening and occasionally round cell infiltration. The sinusoids appear dilated by hyperplasia, often with some desquamation of endothelial cells. The lymph follicles, greatly increased in size, have hyperplastic germinal centers. Edema and moderate congestion are noted frequently. In recurring cases bands of connective tissue are seen to replace the lymphoid elements. In some acute cases, but more frequently in "chronic" or recurring cases, giant cells may be seen which resemble those of tuberculosis. However, these regress without scarring, show no caseation and have been proved negative for tubercle bacilli by means of special stains and bacteriologic methods.

Because of the obscure origin of this disease, the condition of related structures, notably the appendix, has received considerable attention. In the majority of cases of mesenteric adenitis the appendix appears grossly uninvolved,[28] or at most there is some injection of its serosal surface. Some observers report a significantly high incidence of adhesions about the appendix, a situation which is associated with the term "chronic appendicitis." Microscopically, the appendix reveals few if any changes of note. The most commonly reported alteration is that of chronic inflammation,[29] as evidenced by varying degrees of fibrosis in the wall of the organ.

The usual abundance of lymphoid tissue in the appendix of children and young adults raises much doubt as to its pathologic significance. In some cases, the appendix removed during an attack of acute mesenteric adenitis reveals hyperplasia of the lymph follicles and engorgement of the sinusoids similar to that seen in the mesenteric nodes. This is reported by some as "lymphoid appendicitis." Such simultaneous involvement of the mesenteric nodes and the appendix by a process which is similar microscopically favors the view that the condition is one which primarily involves the intestinal lymphatic system (figs. 2 and 3).

While it is not usual, mesenteric adenitis is observed at operation when the primary pathologic changes are in the appendix.[30] All degrees of appendicitis are seen, but involvement of mesenteric nodes has been noted more often in the suppurative and gangrenous form than in the

28. (*a*) Rosenberg, N.: Syndrome of Acute Appendicitis, Am. J. Surg. **58**:365-367, 1942. (*b*) Wilensky.[10] (*c*) Sobel and Stilten.[14a] (*d*) Postlethwait.[15b]

29. Foster, A. K.: Mesenteric Lymphadenitis, Arch. Surg. **38**:131 (Jan.) 1939. Rosenberg.[28a] Urech.[15d]

30. (*a*) Kirkpatrick, W. D.: Mesenteric Lymphadenitis in Relation to Intestinal Obstruction, West. J. Surg. **46**:317-320, 1938. (*b*) Bathe, F. A., and Pate, H. H.: Mesenteric Adenitis Associated with Appendicitis: Analysis of One Hundred and Fifty-Four Cases, Internat. Clin. **4**:77-88, 1941. (*c*) Foster.[1] (*d*) Coleman.[4b] (*e*) Tilley.[14c] (*f*) Segar and Rosenak. [20d]

cases of uncomplicated or "acute catarrhal appendicitis." On an anatomic basis it is illogical to conceive of the mesenteric adenitis as being secondary to the appendical disease. A possible explanation is that the lymphoid hyperplasia occurring as part of a generalized process may produce in the lumen of the appendix significant obstruction and thus favor the supervention of infection and initiate an acute inflammatory process.

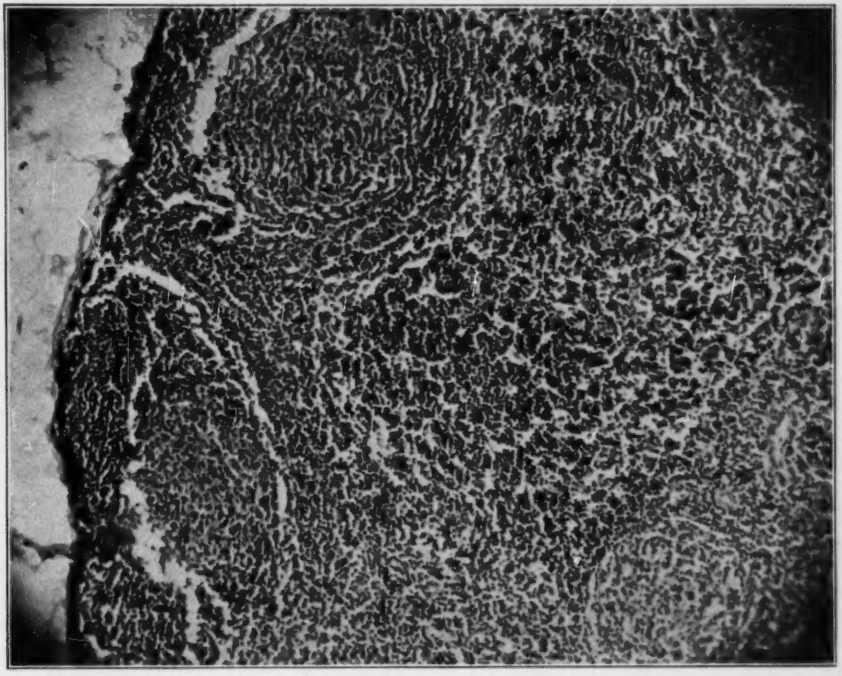

Fig. 2.—Hyperplasia of mesenteric lymph node in a case of mesenteric adenitis.

Another consideration is the involvement of the terminal portion of the ileum. Coleman,[4b] Collins,[16] Tilley,[16c] Rockey,[31] Aird [32] and, more recently Erskine,[33] have called attention to the injection, edema and

31. Rockey, E. W.: Thickening of Terminal Ileum with Mesenteric Adenitis in Children, Northwest Med. **32**:145-146, 1933.

32. Aird, I.: Acute Non-Specific Mesenteric Lymphadenitis, Brit. M. J. **2**:680-682, 1945.

33. Erskine, E. B.: The Pathologic Relationship of Mesenteric Adenitis, Ileitis and Appendicitis, Am. J. Clin. Path. **11**:706-712, 1941.

thickening of the ileum which is observed not infrequently in association with mesenteric adenitis. Aird [32] suggested that possibly there existed some relation between mesenteric adenitis and the acute form of regional enteritis of Crohn. Erb and Farmer,[34] Coffey and Ware [34a] and others [25] have described cases of acute regional enteritis occurring in children. In these cases involvement of the mesenteric nodes was observed. The conservative treatment which is indicated in the acute phase of regional enteritis precludes study of the pathologic process in the ileum in such

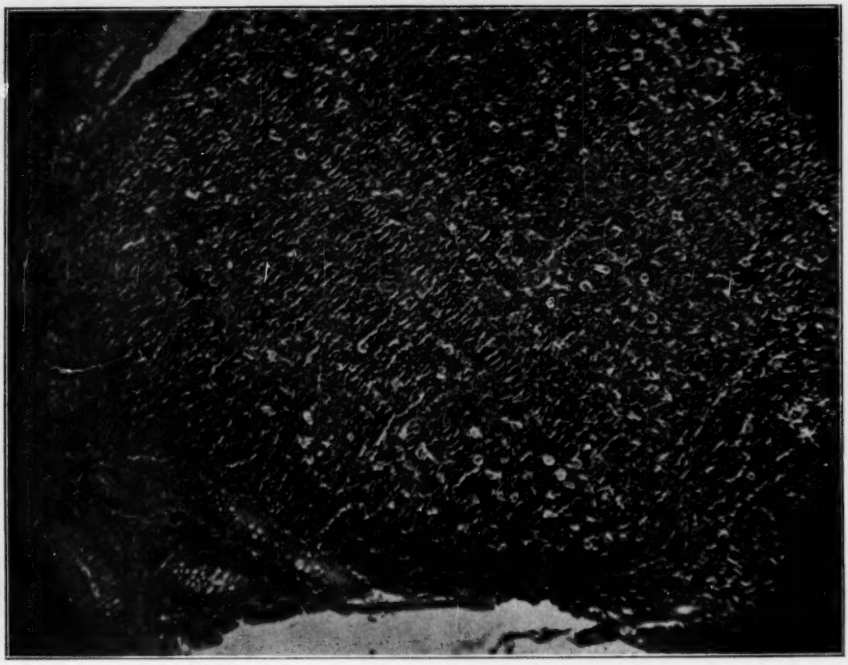

Fig. 3.—Hyperplastic lymph follicle of appendix removed in same case.

cases when mesenteric adenopathy is a concomitant factor. Grossly, however, the ileum in cases of acute regional enteritis shows conspicuous evidence of a violently acute inflammation, whereas in mesenteric adenitis such gross changes in the ileum are absent or minimal.

34. Erb, I. H., and Farmer, A. W.: Ileocolitis, Surg. Gynec. Obst. **61**:6-14, 1935.

34a. Coffey, R. J., and Ware, G. W.: Acute Regional Enteritis, J. Pediat. **32**: 460-464, 1948.

D. D., a white boy aged 8, was admitted to the hospital with the complaint of a sore throat. Two weeks previously a diagnosis of scarlet fever had been made, for which sulfadiazine and penicillin were given. A papular rash which appeared a week before his admission had persisted.

Examination revealed an acutely ill child. The pharynx was acutely inflamed, the right tonsil being covered with an exudate. A papular rash was present on the extremities and face. Examination of the abdomen revealed no abnormalities.

Laboratory data included a white blood cell count of 12,300 per cubic millimeter, with 80 per cent neutrophils and 14 per cent band forms. Urinalysis revealed albuminuria, a trace of acetone and a few clumped white cells.

Penicillin therapy and supportive measures were instituted and, although the temperature rose to 104 F. on the following day, the patient seemed better. On the evening of the second hospital day he complained of generalized abdominal pain, which became more severe during the next twenty-four hours. Vomiting and diarrhea began on the fourth hospital day, after which abdominal rigidity and mild distention became evident.

A diagnosis of appendicitis, possibly a ruptured appendix, with diffuse peritonitis was made, and operation was advised. When the peritoneal cavity was opened, approximately 750 cc. of serosanguineous fluid was evacuated.

Beginning with the distal jejunum and terminating abruptly at the ileocecal valve the small bowel was fiery red and edematous. The mesenteric nodes were enlarged. The mesentery of the small bowel was not appreciably thickened or inflamed. The cecum and appendix were not involved. The appendix was not removed.

Postoperatively, the course was uneventful except for an allergic urticaria, relieved by the use of diphenhydramine hydrochloride (benadryl hydrochloride®). The patient was discharged on the tenth day in the hospital.

CLINICAL MANIFESTATIONS

The clinical aspects of mesenteric adenitis are well known and merit only a brief review.

Typically, the onset of the acute episode is sudden, and the presenting symptom is abdominal pain. The patient, most often under 12 years of age, may have been asymptomatic prior to the onset. Careful questioning often elicits additional information which is of assistance in the differential diagnosis. A history of previous similar episodes of abdominal pain is common.[35] A preceding or coexistent infection of the upper respiratory tract is reported in a high percentage of cases.[36]

The abdominal pain is usually generalized, often maximal about the umbilicus or to the right and tends to be crampy in character. Between spasms of pain the patients may appear normally active, and even during spasms they tend to be more active than those with acute appendicitis.

35. Foster.[1] Coleman.[4b] Sobel and Stilten.[14a] Adams and Olney.[15a] Rosenberg.[28a] Bathe and Pate.[30b]

36. Emmett and others.[11a] Adams and Olney.[15a] Postlethwait and others.[15b] Wise.[21]

Vomiting is a fairly constant occurrence, is often repeated and leads to mild alkalosis and dehydration. Nausea may or may not be present. Anorexia is a common feature, sometimes preceding the onset of pain by a few days or longer. The onset of mild diarrhea early in the illness occurs frequently, but constipation is often present throughout the illness.

On examination the patient may not appear ill at the time or may complain only of mild generalized abdominal pain. A high incidence of tonsillar and/or pharyngeal inflammation is reported,[37] and cervical lymphadenopathy is common.[16] Rarely are any positive findings elicited on examination of the chest.

The abdomen is diffusely tender, with maximal tenderness around the umbilicus or at a point above and medial to McBurney's area. Equal tenderness over the entire abdomen may be noted. A moderate degree of rebound tenderness is frequent. Shifting tenderness, described as being pathognomic by Klein,[26b] is an unreliable finding. Rigidity of the abdomen is not prominent. When it is present, more severe intra-abdominal pathologic changes should be suspected.[38] In persons of slender habitus or those in whom palpation is facilitated by relaxation of the abdominal wall, abdominal lymph nodes are occasionally palpable. On rectal examination, mild bilateral tenderness is usually present.

The occurrence of splenomegaly in this condition has been noted only rarely in the past. However, in the experience of one of us (R. J. C.) palpation of the lower pole of the spleen on deep inspiration is a significant finding. As a result of a deliberate effort to identify splenomegaly in mesenteric adenitis during the past four years, he has been successful in demonstrating its occurrence in approximately 40 per cent of cases. The importance of this physical finding is evidenced by the fact that in a number of atypical cases it has been the deciding factor against a diagnosis of appendicitis and subsequent surgical intervention.

A. K., a white boy aged 7, was admitted to the hospital complaining of malaise, headache, abdominal pain of three days' duration and diarrhea. He had vomited once. No previous or concurrent infection of the upper respiratory tract was noted, and he had not had previous similar episodes. The admission temperature was 101.8 F. On examination abdominal tenderness was elicited in both lower quadrants, more marked on the right, with slight rebound tenderness. The lower pole of the spleen was palpable on deep inspiration. Pertinent laboratory data included a white blood cell count of 14,000 per cubic millimeter, with 87 per cent polymorphonuclear leukocytes; a heterophile index of 1:20, and a 4 plus reaction for acetone in the urine.

A diagnosis of mesenteric adenitis was made, and it was felt that surgical intervention could be safely deferred. Phthalylsulfathiazole was administered orally.

37. Foster.[1] Emmett and others.[11a] Goldberg and Nathanson.[17] Wise.[21]

38. Wilensky, A. O.: Chronic Intra-Abdominal Lymphadenopathy, Surgery 9:787-820, 1941.

The fever regressed, the diarrhea subsided and the abdominal complaints disappeared within forty-eight hours. The aforementioned splenomegaly had disappeared ten days later.

However, excessive dependability should not be placed on this finding inasmuch as mesenteric adenitis and acute appendicitis may coexist.

W. N., a white boy aged 9, was admitted to the hospital with a history of six hours of abdominal pain, nausea and vomiting. Three diarrheal stools had been passed since the onset. A history of several similar episodes during the previous year was elicited. One week prior to his admission he had an infection of the middle ear which responded to penicillin therapy. The admission temperature was 99.6 F. On examination diffuse lower abdominal tenderness, most marked in the right lower quadrant, was found. Slight rebound tenderness and minimal muscle rigidity were noted on palpation of the right lower region of the abdomen. The lower pole of the spleen was palpable. On rectal examination significant tenderness of the right rectal wall was elicited. Laboratory data included a white blood cell count of 14,300, with 83 per cent polymorphonuclear forms. A trace of acetone was present in the urine.

In spite of our diagnostic impression of acute mesenteric adenitis, the unusually sharp localization of physical findings in the right lower quadrant led us to advise surgical intervention, and at operation the appendix was acutely inflamed with a fibrinous exudate covering its distal one third. Numerous enlarged, reddened nodes were found in the mesentery of the ileum and jejunum. The postoperative course was uneventful.

Laboratory data are not of great assistance in diagnosis. Leukocytosis of moderate degree is usual. However, a concomitant infection of the upper respiratory tract may alter the white blood cell count appreciably. While a polymorphonuclear leukocytosis is the rule, it has been observed by some [39] that lymphocytosis is frequent in cases of mesenteric adenitis. Urinalysis commonly shows acetonuria and occasionally a few white cells microscopically.

Accurate diagnosis is difficult in the presence of variable and atypical clinical manifestations. The history most often suggests acute appendicitis, while examination of the patient may not support this impression. In such circumstances one should think of mesenteric adenitis. Of course, other causes of an acute condition within the abdomen must be ruled out. The causes of acute abdominal pain in children may be classed as medical or surgical. Among medical conditions deserving consideration may be enumerated: pneumonia, pyelitis, gastroenteritis, rheumatic fever, diabetic acidosis, typhoid, sickle cell anemia and tuberculous enteritis. The surgical conditions requiring differentiation include appendicitis, intussusception, strangulated hernia, intestinal obstruction, Meckel's diverticulitis and regional enteritis. Of prime importance is the decision as to whether or not surgical intervention is indicated.

39. Coleman, E. P.: Mesenteric Lymphadenitis, Am. J. Surg. **72**:879-882. Urech.[15d]

TREATMENT

Because of the uncertainty of diagnosis, the treatment of acute mesenteric adenitis is usually surgical.[40] In other words, if acute appendicitis cannot be ruled out, laparotomy is indicated. Most of the patients are therefore subjected to operation with a preoperative diagnosis of appendicitis. This should not be construed as lack of diagnostic acumen but rather as good judgment. Further, the diagnosis of mesenteric adenitis cannot be confirmed except at operation.

For reasons which are not obvious, most of these children are completely relieved of abdominal pain after appendectomy.[41] Reports vary on the incidence of recurrence of abdominal symptoms,[42] but at least two thirds have no further trouble postoperatively. Some patients have milder attacks than those experienced preoperatively, while still others describe a different type of pain occurring at intervals after operation. The percentage of recoveries after appendectomy seems too high to be coincidental, but no cogent explanation exists.

Removal of mesenteric nodes at operation has no therapeutic value and is done to permit bacteriologic and/or histologic studies. Formerly this procedure was condemned because of the potential danger of disseminating an infectious agent and because of the technical difficulty sometimes involved. Good surgical technic and the availability of chemotherapeutic agents, however, seem to make the removal of nodes more an apparent danger than a real one.

After recovery from operation, an improved dietary and hygienic regimen should be instituted, inasmuch as many of the patients seem in need of general care.

REVIEW OF CASES

During the five year period from 1943 to 1947, inclusive, mesenteric adenitis was diagnosed in 184 cases at the Children's Hospital. Data obtained from the clinical records of these patients comprise the material for this report.

Early in this study it became obvious that these cases fell into two large groups, namely, those in which symptomatic treatment was given, and those in which surgical intervention was employed. The nonsurgical group consisted of 99 cases, in which the clinical picture was sufficiently suggestive of mesenteric adenitis, or, stated differently, in which the diagnosis of acute appendicitis was sufficiently excluded to make deferment of operative intervention safe. In this group the diagnosis was, therefore, entirely on clinical grounds and lacked positive confirmation.

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40. Lamson, O. F.: Mesenteric Lymphadenitis and Acute Appendicitis, S. Clin. North America **11**:5 and 1061-1064, 1931. Wilensky.[8] Rosenburg.[14d] King.[15e]

41. Coleman.[4b] Bathe and Pate.[30b]

42. Rosenburg.[14d] Postlethwait.[15b]

The surgical group numbered 85 cases; in these exploration was carried out, and in most of them the preoperative diagnosis was acute appendicitis. While it was necessary so to divide these cases because of absence of a proved diagnosis in the nonsurgical group, certain similarities in the clinical and laboratory findings favor the impression that in the entire series a single entity was represented.

Nothing significant was encountered in the race distribution, the ratio of white and Negro patients being similar to the over-all ratio among patients admitted to the hospital.

The sex incidence of this condition was not remarkable, 98 cases involving boys and 86 girls.

TABLE 1.—*Symptoms and Physical Findings in 184 Cases*

	Number	Percentage
Abdominal pain as initial symptom	143	78
Vomiting	109	59
Anorexia	33	18
Diarrhea	22	12
Constipation	32	17
Preceding infection of the upper respiratory tract	48	26
Previous similar episodes	50	27
Tonsillitis and/or pharyngitis	99	54
Positive pulmonary findings	4	2
Lymphadenopathy	57	31
Abdominal tenderness	138	75
Abdominal rigidity	58	31
Rebound tenderness	26	14
Abdominal masses	10	5
Splenomegaly	1	0.5
Hepatomegaly	3	1.5

The average age of these patients was 6.7 years; the youngest was 5 months of age and the oldest 13 years (the upper age limit eligible for admission to this hospital).

During the months in which infections of the upper respiratory tract are prevalent, a distinctly higher seasonal incidence of mesenteric adenitis was found. During the six month period of October through March, 63.6 per cent of the cases occurred. This finding was interpreted as favoring the concept that mesenteric adenitis is commonly associated with infection of the upper respiratory tract.

The duration of symptoms prior to the patients' admission to the hospital averaged fifty-two hours in the nonsurgical group, while in the surgical group it averaged thirty-eight hours. There were considerable fluctuations within each group, and it was noteworthy that in some instances symptoms had been present for seven to ten days.

The percentage incidence of the common symptoms and signs is shown in table 1. The significant differences in clinical data in the two

groups are recorded in table 2. The outstanding initial symptom was abdominal pain, which characteristically was periumbilical or distributed throughout the entire lower region of the abdomen. In 25 per cent of the cases the pain was confined to the periumbilical region throughout the course of the illness, while in 31 per cent the initial pain was generalized.

In one third of the cases localization of the pain in the right lower quadrant occurred, but in only 11 per cent was this localization present as an initial symptom. It should be stated at this point, however, that localization of pain and tenderness in the right lower quadrant is rarely as distinct as that seen in acute appendicitis. Vomiting occurred in a majority of cases. Anorexia was uncommon. Diarrhea developed after the onset of symptoms in 12 per cent, being more frequent in the nonsurgical group. Constipation was noted in about 17 per cent.

TABLE 2.—*Significant Differences in Surgical and Nonsurgical Groups*

	Nonsurgical (99)		Surgical (55)	
	No.	%	No.	%
Diarrhea	14	14.1	8	9.4
Preceding infection of the upper respiratory tract	25	25.4	13	15.3
Previous similar episodes	30	30.3	20	23.5
Tonsillitis and/or pharyngitis	73	73.7	26	30.6
Abdominal rigidity	20	20.2	38	44.7
Rebound tenderness	11	11.1	15	17.7
Abdominal masses	1	1.1	9	10.6

On physical examination these patients did not appear seriously ill at the time of their admission to the hospital. The temperature was only slightly elevated, averaging 100.2 F. In 74 per cent of the nonoperative group, inflammation of the tonsils and/or pharynx was noted, while these findings were identified in approximately one third of the patients operated on. Objective evidence of pulmonary disease was rarely encountered, occurring in only 4 cases in this series.

Demonstrable lymphadenopathy, usually involving the anterior or posterior cervical nodes, occurred in about 30 per cent. Whether this finding is the result of an infection of the upper respiratory tract or is a manifestation of a general lymphatic involvement is questionable.

Abdominal tenderness, characterized by its diffuseness, and varying in degree but usually moderate, was a rather constant finding. Rebound tenderness was infrequent. A palpable abdominal mass was rarely encountered. In a single case in the nonsurgical group, "small, firm, movable masses" were described. In the surgical group, previously palpated masses were identified at operation as an intussusception in 3 cases and as palpable mesenteric nodes in 6 cases. A palpable spleen

was reported in only 1 case. This is in contrast to the previously mentioned personal experience of one of the authors.

There were no significant differences in the laboratory data in the surgical and nonsurgical groups. The white blood cell count averaged 11,500; extremely high leukocyte counts, over 20,000, were very uncommon. Moderate to marked lymphocytosis was found in 25 per cent. Occasionally slight to moderate eosinophilia was noted.

As a sequel to fluid lost through vomiting or diarrhea, acetonuria was encountered in 20 per cent of the cases. The identification of white cells in the urine, occasionally in clumps, occurred in a strikingly large number of cases (40 per cent), while hematuria and bacteriuria were rare. No cogent explanation for the occurrence of white cells in the urine was manifest, although this finding is not uncommon in the course of other diseases of the extraurinary tract in children. In 7 cases the heterophile determination for mononucleosis gave negative results.

In 50 cases the primary pathologic process was mesenteric adenitis. This varied in degree, but no cases of suppurative adenitis occurred. Tuberculous mesenteric adenitis was not identified in any case. In 22 cases the operator called attention to gross evidence of appendical disease, usually described as subacute or chronic appendicitis, in addition to the enlargement of the mesenteric nodes. In 3 cases of intussusception conspicuous mesenteric lymphadenopathy was noted.

Of the 3 deaths in the series, 2 occurred in the nonsurgical group. Mesenteric adenitis was identified at postmortem examination in both instances. In one acute splenitis with splenic tumor and hepatomegaly were found; in the other pneumonia was present. The death in the surgical group occurred one hour after operation. At autopsy rheumatic heart disease with myocarditis, early interstitial pneumonia and mesenteric lymphadenitis were found.

RECURRENT DISLOCATION OF THE SHOULDER REPAIRED BY THE MAGNUSON-STACK OPERATION

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THE PROBLEM of devising an operative procedure for the surgical repair of recurrent anterior and inferior dislocations of the shoulder joint has been given a great deal of thought by many surgeons over an extended period. It is apparent from the innumerable procedures developed and described that none of them is entirely satisfactory. In instances in which the recurrence rate has been lowest, the surgical procedure performed is complex and complicated and does not lend itself well to performance by the average surgeon, who frequently is called on to repair these dislocations.

This paper is intended to consider briefly the anatomic and pathologic features found in the disorder and to present a preliminary report on the results obtained in 13 cases in which repair was carried out by the technic developed and described by Magnuson and Stack.[1] The follow-up period was from six months to two years in the individual cases, and it is recognized that this is a short period for complete evaluation. It may be noted, however, that the majority of recurrences following surgical repair of this condition take place within the first twelve months after operation. It was felt that a report at this time would act as a stimulus to many surgeons to use this procedure, thereby bringing to light a larger composite series in which the results of the operation in comparison with those previously tried would truly be evaluated.

ANATOMIC FEATURES

The shoulder joint is a ball and socket, freely movable type in which the ball is considerably larger than the socket. Only about 25 per cent of the surface of the head of the humerus is in contact with the

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1. Magnuson, P. B., and Stack, J. K.: Recurrent Dislocation of the Shoulder, J. A. M. A. **123**:889 (Dec. 4) 1943.

smooth and shallow glenoid cavity of the scapula at any one time. This bony configuration speaks for great mobility but not for stability. The lack of stability of the bony elements is partially compensated by the muscles about the joint, the glenoid labrum and capsule with its ligaments. These muscles are intimately associated with the capsule superiorly and posteriorly, forming a musculotendinous cuff; they are the supraspinatus and infraspinatus and teres minor muscles inserting in the top of the greater tuberosity, and they hold the humeral head up and close to the surface of the glenoid. The fourth muscle, the subscapularis, inserts in the lesser tuberosity, reenforcing the anterior surface of the joint.

The glenoid labrum is a fibrocartilaginous ring which is attached about the periphery of the glenoid cavity and aids in deepening the socket. This structure is triangular in cross section, with its base at the attachment to the glenoid lip and its apex a free edge interposed between the head of the humerus and the capsule. The capsule of the joint is roughly cylindric in shape, with the proximal portion attached to the scapular neck and base of the glenoid labrum and the distal end attached to the anatomic neck of the humerus. The capsule is reenforced by the coracohumeral ligament superiorly and the three glenohumeral ligaments anteriorly and by the blending of the tendinous insertion of the supraspinatus and infraspinatus, teres minor and subscapularis muscles into the capsule.[2]

PATHOLOGIC FEATURES

A great deal of discussion and study has been carried out in an attempt to find a single essential feature which is responsible for recurrent dislocations of the shoulder joint. Almost every structure in and about this joint has been incriminated at one time or another. Most surgeons interested in this field feel that the causes are varied and multiple.

At the present time three theories remain popular. The first, and most convincing, is that muscle imbalance is the essential feature. The muscles about the joint are the chief factors in maintaining the joint surfaces in normal contact and relationship, and it is probable that changes due to injury can cause this disorder. Magnuson and Stack[1] emphasized the importance of the subscapularis muscle and tendon in protecting the integrity of the anterior portion of the joint. They feel that a decrease in the efficiency with which the musculotendinous cuff muscles at the superior portion of the joint hold the head in place during abduction and external rotation of the humerus also lessens the protecting

2. Cunningham, D. J.: Cunningham's Textbook of Anatomy, edited by A. Robinson, New York, William Wood & Company, 1923, pp. 323-324.

ability of the tendinous portion of the subscapularis muscle and allows a wider gap to occur between the lower edge of the subscapularis and the insertion of the long head of the triceps (figs. 1 and 2). This is the weakest and the most redundant portion of the capsule, and it is in this area that most anterior dislocations occur. In support of this theory these authors pointed out that the glenoid cavity is very shallow and smooth and that in cases of paralysis of the muscles about the shoulder joint dislocations are easily produced, even the weight of the arm being sufficient to separate the surface of the head of the humerus from the glenoid cavity for a distance of one-half inch (1.27 cm.). Some surgeons have also noted at operation for the repair of recurrent dislocations that the tendinous portion of the subscapularis muscle is thin and tends to ride high on the anterior surface of the humeral head and that frequently on abduction and external rotation the tendinous cuff slips upward beneath the coracoid process and up over the head, lending practically no support to this anterior and inferior weak area of the capsule (fig. 2).

The second of the theories is the one popularized by Bankart.[3] He states that a constant defect is present in all these shoulders and that the lesion is an avulsion or tear of the glenoid labrum and/or capsule from its normal attachment to the glenoid rim and the anterior aspect of the neck of the scapula. The destruction of the normal supporting glenoid labrum at the anterior edge of the glenoid cavity allows the head of the humerus to slide forward and downward out of its normal position whenever the arm is abducted and externally rotated. Bankart also has felt that an initial injury to the posteriorly extended arm forcing the humeral head forward and tearing the attachment of the glenoid labrum predisposes to recurrent dislocations of the shoulder joint.

The third of the theories is that at the time of the initial injury the cartilage and bone of the posterolateral portion of the head of the humerus is damaged by the anterior edge of the glenoid cavity and that a notched or flattened defect of this portion of the humeral head results. The mechanism of recurrent dislocation is described as follows: With abduction and external rotation of the humerus the humeral defect first faces the glenoid, and then with continued external rotation the anterior rim slides into the hollow of the notch, forcing the head forward and partially out of the glenoid cavity. Widen[4] describes the defect as one constantly found in this disorder and feels that it is the essential lesion.

In a series of 393 cases from the recent literature, there were lesions of the glenoid labrum or the capsule at the anterior glenoid rim in 287

3. (*a*) Bankart, A. S. B.: Pathology and Treatment of Recurrent Dislocation of the Shoulder Joint, Brit. J. Surg. **26**:23, 1938; (*b*) Symposium on Treatment of Recurrent Dislocation of the Shoulder Joint, J. Bone & Joint Surg. **30B**:46, 1948.

4. Palmer, I., and Widen, A.: Bone Block Method for Recurrent Dislocation of the Shoulder, J. Bone & Joint Surg. **30B**:53, 1948.

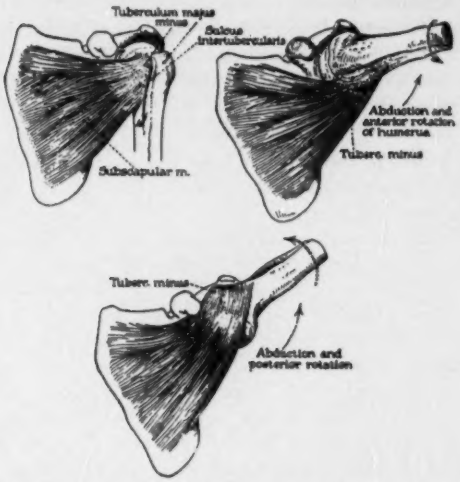

Fig. 1.—Attachment of subscapularis to lesser tuberosity of humerus. (Figs. 1 to 5, courtesy of Magnuson, P. B., and Stack, J. K.: J. A. M. A. **123**:889-892 [Dec. 4] 1943.)

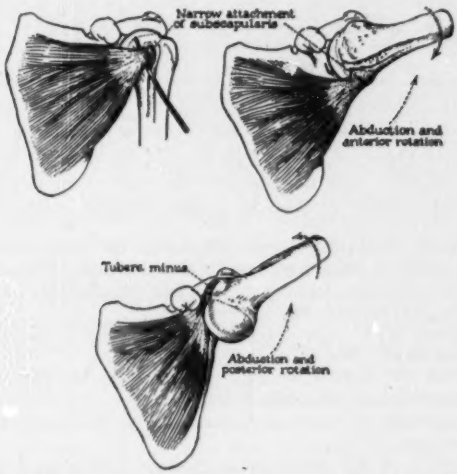

Fig. 2.—Tendon slipping between head of humerus and coracoid when arm is placed in abduction and extension.

when these structures were exposed at the time of operation. Of the 249 patients studied roentgenologically, 199 had lesions of varying degrees of severity in the humeral head. Because muscle imbalance is a physiologic rather than an anatomic change, this factor is difficult of evaluation by any visible means.

OPERATIONS

Many operative procedures have been developed and described in the treatment of recurrent dislocations of the shoulder. At the present time probably the most frequently performed operations are ones described by Nicola,[5] with the various modifications, and by Bankart.[3b] Bone block operations [4] are popular in the Scandinavian countries. The tenosuspension operation devised and described by Henderson [6] has many advocates. Gallie's [7] fascial operation has been successful in his hands. The Putti-Platt operation, named after the two originators by Osborne-Clark,[8] is gaining in popularity, and the Magnuson-Stack [1] operation is being more widely used in this country. Of these various methods the Nicola operation is the least efficient. About 20 to 25 per cent of recurrences can be expected on the basis of reports of large series of cases. The reports on the other operative methods reveal 90 to 95 per cent good results in a large series of cases.[9] Loyal supporters and critics of each of the procedures described can be found.

The Nicola operation has been criticized on the basis of a high rate of recurrences, painful shoulders, technical difficulties and because, as shown by some experimental work, a tendon passing through a bony tunnel becomes attenuated into a thin fibrous cord of no appreciable strength.

The Bankart operation has been deemed technically difficult by many, and this has probably limited its general use. Some authorities claim that the extensive dissection necessary results in a dense scar tissue reaction in the region of the anterior glenoid lip and that this accounts for its success more than the reattachment of the torn glenoid labrum. A considerable number of cases have been reported in which limitation

5. Nicola, T.: Recurrent Anterior Dislocation of the Shoulder: A New Operation, J. Bone & Joint Surg. **11**:128, 1929; Anterior Dislocation of the Shoulder: the Role of the Articular Capsule, ibid. **24**:614, 1942; Recurrent Dislocation of the Shoulder, ibid. **16**:663, 1934.

6. Henderson, M. S.: Tenosuspension for Dislocation of Shoulder, S. Clin. North America **23**:927, 1943.

7. Gallie, W. E., and Le Mesurier, A. B.: Recurring Dislocation of the Shoulder, J. Bone & Joint Surg. **30B**:9, 1948.

8. Osborne-Clark, H.: Habitual Dislocation of the Shoulder, J. Bone & Joint Surg. **30B**:19, 1948.

9. Bankart, A. S. B.: Recurrent or Habitual Dislocation of the Shoulder Joint, Brit. M. J. **2**:1132, 1923. Bankart.[3] Gallie.[7] Osborne-Clark.[8] Palmer and Widen.[4]

of motion was troublesome and a painful joint a not infrequent result of this operation. Severe limitation of motion and pain has also been found after the bone block procedures.

The tenosuspension operation described by Henderson [6] has been used widely. He was of the opinion that an operative procedure that involved a simpler technic than those advocated by Bankart and Gallie should be seriously considered. His results gave a high percentage of cures. Basically, the operation consisted of using a segment of the peroneus longus tendon which was threaded through drill holes made in the acromion process and the humeral head and suturing together the cut ends of the tendon. When the tendon was properly placed and drawn snugly across the joint, recurrences were infrequent.

One of the most recently proposed operations has been advanced by Magnuson and Stack.[1] This operation has many advantages, one of the greatest of which is its ease of performance. Because of the dissatisfaction with the results obtained by other groups and by one of us (L. T. P.) with the various procedures described and the belief that this operation is based on sound anatomic and physiologic principles, the Magnuson-Stack procedure has been performed at this hospital in 13 cases of recurrent dislocation of the shoulder.

OPERATIVE TECHNIC

A 4 inch (10-16 cm.) incision is made on the anteromedial aspect of the arm from the tip of the acromioclavicular joint downward. The deltoid muscle is split in the direction of its fibers, and the anterior aspect of the shoulder joint is exposed. The arm is then slightly abducted and externally rotated so as to bring into view the musculotendinous attachment of the subscapularis to the lesser tuberosity of the humerus (fig. 1).

By placing the prongs of a large towel clip just beyond the point of insertion of this muscle, it can be used as a tractor, and by elevating this structure from the bone the freeing of its attachment to the humerus and capsule can be expedited and simplified. An incision is then made along the upper and lower borders of the tendon through the capsule and the tendon cut from the bone, thus freeing these structures from the area of their insertion into the lesser tuberosity (fig. 3*A*, *C* and *D*).

Magnuson and Stack, in their original operation, detached the insertion of this muscle by removing a wedge of bone from the lesser tuberosity and transplanted it into a wedge-shaped defect made in the greater tuberosity. That part of their technic has not been followed in this series. After the musculotendinous attachment is freed, the extremity is placed in internal rotation in order to bring the bicipital groove and greater tuberosity into view. At this point the joint cavity can be inspected for any evidence of tears or bony defects. With traction on the towel clip attached to the detached tendon of the subscapularis muscle and with

the arm internally rotated, a position on the upper portion of the greater tuberosity, lateral to the bicipital groove, is selected for the site of transplantation of the tendon so as to bring about at least 50 per cent and not more than 75 per cent limitation of external rotation of the arm. Then, by means of a thin-bladed chisel, a groove about 1 inch (2.5 cm.) in length and a quarter of an inch (0.64 cm.) in width and depth is made in the greater tuberosity. By means of a towel clip, at least three to four holes are made in the lateral wall of this prepared groove through which double strands of 00 silk sutures are passed.

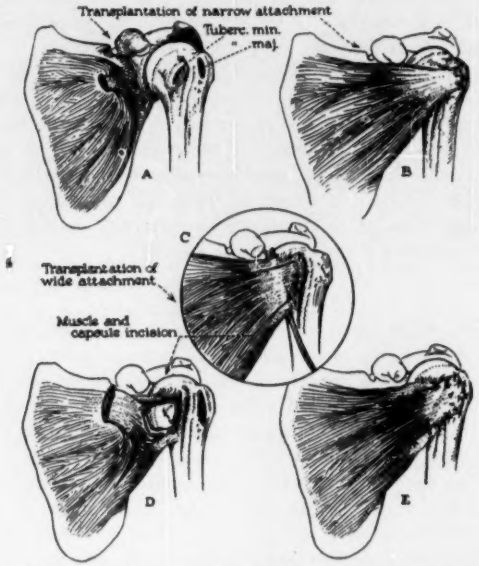

Fig. 3.—Medial reflection of tendinous attachment and exposure of head of humerus. *B* and *E*, sutures placed after transplantation of subscapularis tendon and muscle.

Sutures are then taken into the cut ends of the subscapularis tendon as mattress stitches and tied, the cut end of the tendon being transplanted into the depth of the groove (fig. 3 *B*). The upper and lower borders of the tendon are then sutured, with the same type of sutures, to the surrounding capsular structures, thereby closing the defect in the joint and reenforcing the transplantation. This step in the procedure will prevent an upward slipping of the tendon toward the coracoid process when the arm is abducted (fig. 3 *E*). This part of the operation is considered very important and should not be eliminated.

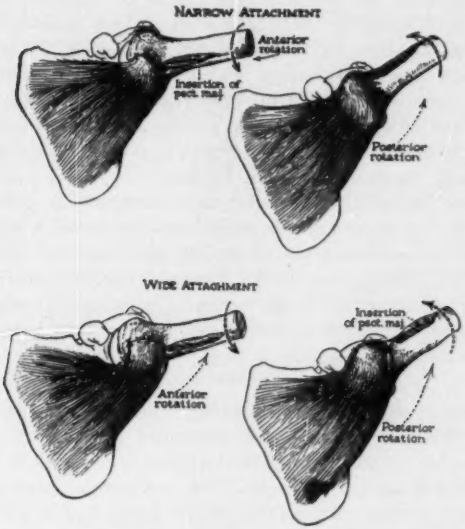

Fig. 4.—Method of attachment of muscle and tendon under head of humerus.

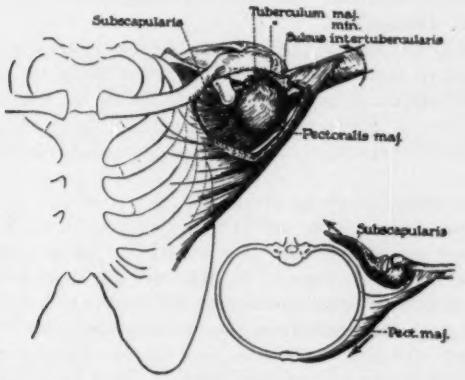

Fig. 5.—Subscapularis muscle and tendon wind firmly around head of humerus.

The arm should then be rotated externally and internally, carefully and without force, to determine the degree of limitation of external rotation, which should be about 50 per cent. This maneuver will demonstrate the broad musculotendinous cuff, formed by the transplanted subscapularis muscle and tendon, which is present to prevent a downward and forward slipping of the head (figs. 4 and 5) and which will counteract the strong external rotators of the arm. The wound is closed in layers with 000 silk. The upper extremity is then immobilized against the chest with the use of a Velpeau bandage.

Complete immobilization of the upper extremity is maintained for three weeks. At the end of this period shoulder exercises are instituted in the form of active and passive motion and pendulum motion. The patient wears a sling for one week. External rotation is guarded against for a period of about four to six weeks. The patient is advised against any occupation or physical exercise which involves forced abduction and marked external rotation.

RESULTS

Thirteen shoulders were operated on in the same number of patients (table). The first operation was performed on April 15, 1947, and the last on Oct. 6, 1948. Of the total number of dislocations, 7 involved the left shoulder and 6 the right. The recurrences, prior to surgical operation, occurred a number of times over a period of at least one year, varying from five to fifteen times. In 2 cases the patients had undergone previous repairs in which a Nicola type of procedure was performed. In both cases the recurrences were frequent, taking place at least eight times, and the Magnuson repair was performed almost two years after the original operation.

In 3 cases the patients had grand mal attacks of epilepsy which had caused frequent recurrences; however, after the Magnuson repair there were no recurrences in any of these cases. In one the follow-up period was eight months and in another five months. The third patient died eight months after operation; the cause was not included in the follow-up report.

The maximum follow-up period was two years and the minimum one-half year. The average age of the group was 26 years, the oldest being 40 and the youngest 20. The majority of patients did moderate or heavy work or were engaged in athletics. The average duration of symptoms prior to surgical intervention was 3.2 years.

A follow-up by questionnaire was made in December 1948, and 4 patients were seen and examined in the outpatient department by one of us (L. T. P.) during the past four months. There have been no recurrences to date in the entire series. The majority of patients revealed some limitation of external rotation; this varied from 20 to 50 per cent. Fifty-four per cent of the patients complained of occasional pains about the shoulder joint.

Most of the patients returned to some gainful occupation in two to four months. Fifty per cent are engaged in heavy work, and several are students who participate in some form of athletics. One patient has returned to his original work as athletic director.

Summary of Cases

Patient	Age	Original Injury, Shoulder	Frequency	Previous Repair	Magnuson Operation	Follow-up Study
L. H. L.	40	Right, 1944	12 times	0	4/15/47	On 8/16/48 and 12/9/48—No dislocations; returned to heavy work in 4 months; no discomfort; 25% limitation of external rotation
L. G.	32	Right, 1945	Innumerable times	0	5/9/47	On 12/9/48—No dislocations; returned to work; no disability; slight pain in shoulder; slight limitation of external rotation
J. H.	20	Left, 1946	Innumerable times	0	6/23/47	On 12/9/48—No dislocations; returned to heavy work in 6 months; no complaints; no handicaps; good free motion
A. S.	28	Left, 1944	Innumerable times	0	7/9/47	On 12/9/48—Father reported patient died 4/15/48, cause not given; patient had epilepsy, grand mal type; no recurrence noted or reported
V. P.	22	Left, 1946	7-8 times	0	7/10/47	On 1/14/49—No dislocations; returned to heavy work in 10 months; no pain or discomfort; 50% limitation of external rotation
M. E.	21	Left, 1942	12 times	0	7/18/47	On 12/9/48—No dislocations; no disability, able to work; engaged in athletics; 25% limitation of external rotation
C. E. G.	29	Left, 1947	5 times	0	10/1/47	On 12/9/48—No dislocations; returned to moderate work in 2 months; no complaints; slight limitation of external rotation; this patient has epilepsy, grand mal type
H. H. H.	23	Right, 1944	Once every 2 weeks; recurrences frequently followed Nicola operation	Nicola January 1946	12/19/47	On 2/14/49—No dislocations; returned to farm labor in 4 months; occasional pain in shoulder; 40% limitation of external rotation
E. M. S.	31	Left, 1939	Innumerable times; 8 times following Nicola operation	Nicola November 1946	2/9/48	On 12/9/48—No dislocations; occasional pains in shoulder; slight limitation of external rotation
S. W. S.	23	Left, 1946	Innumerable times	0	5/27/48	On 12/9/48—No dislocations; returned to heavy work in 3½ months; slight discomfort in shoulder; slight limitation of external rotation
A. M.	30	Left, 1943 Right, 1944	12-15 times for each, usually following grand mal seizures	0	7/26/48,* right shoulder	On 12/9/48—No dislocations; returned to work in 5 months; slight pain in right shoulder; no limitation of motion
H. I. W.	21	Right, 1945	Innumerable times	0	8/20/48	On 1/14/49—No dislocations; occasional discomfort in shoulder; 50% limitation of external rotation
W. E. E.	25	Right, 1945	Once a week	0	10/6/48	On 12/9/48—No dislocations; occasional pain in shoulder; slight limitation of external rotation

COMMENT

The results to date as reported by Magnuson and Stack,[10] Giannestras [11] and us appear encouraging. One realizes that the combined series represents less than 100 cases which have been followed from six months to three years and that further observation is necessary to

10. Magnuson, P. B.: Treatment of Recurrent Dislocation of Shoulder, S. Clin. North America **25**:14, 1945. Magnuson and Stack.[1]

11. Giannestras, N. J.: The Magnuson-Stack Procedure for Recurrent Dislocation of the Shoulder, Surgery **23**:794, 1948.

evaluate fully this procedure as compared with the other operations previously advocated. It is significant, however, that in the three groups reported on only two recurrences have developed; these were in Giannestras' group,[11] and he felt that they were not a result of the operation as described but were due to the failure of the operator to suture the upper and lower aspects of the transposed tendon to the surrounding capsular structures. Since most recurrences take place within the first twelve months after operation and since the majority of the cases in this combined series have been followed beyond that period, the recurrence rate so far has been extremely low, lower than in any reported series in which other methods of repair were used. Since the only recurrences to date have been the result of faulty technic, the procedure described by Magnuson and Stack appears to have great promise and merit and probably will assume a top position in the repair of recurrent dislocations of the shoulder in the future.

SUMMARY AND CONCLUSIONS

1. The Magnuson-Stack procedure was successful in 100 per cent of the 13 patients in this series, with a follow-up of six months to two years. A description of the operative technic is presented. The majority of patients revealed some limitation of external rotation of the arm, varying from 20 to 50 per cent, and 54 per cent complained of occasional pains about the shoulder which was operated on. Most of the patients returned to some gainful occupation in two to four months; 50 per cent are engaged in heavy work, and several are students participating in athletics.

2. The Magnuson-Stack operation appears to be a simpler, more easily performed and more logical procedure than many of the others so far advocated and described. This report is presented with the hope that others will use the operation and in that way a sufficient number of cases will be accumulated over the years so that definite conclusions and comparisons can be made and the operation finally evaluated and placed in its true position.

NOTE.—No recurrences have been noted as of May 1, 1950.

USE OF HEPARIN IN THE PREVENTION OF PERITONEAL ADHESIONS

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A NUMBER of attempts have been made to prevent the formation of intraperitoneal adhesions on the assumption that the blood coagulation mechanism was a necessary or at least an important factor in adhesion formation. Thus, Pope [1] reported a series of experiments on rabbits in which sodium citrate was employed to lower the concentration of calcium ions with the hope of preventing adhesion formation by interfering with the coagulation mechanism. Although he reported favorable results by this method, Sweet, Chaney and Willson [2] and Kubota [3] were unable to confirm them.

Lehman and Boys [4] suggested the use of heparin intraperitoneally in the prevention of the formation and reformation of adhesions. In most of their experiments, adhesions were produced in dogs at a preliminary operation and then divided at a second operation. Heparin was then injected intraperitoneally at intervals, and the number of adhesions found after suitable intervals of time was determined. The results were compared with the results of a control series in which heparin was not used. The number of adhesions reformed was reduced from 1.57 times the number divided to 0.26 times the number divided. In another experiment (with rabbits), 26 animals used as controls showed adhesions, while they developed in only 1 of 10 animals given heparin.

These authors also reported 14 clinical cases in which heparin was used.[4c] One of the patients in this series died of hemorrhage. No

1. Pope, S.: The Use of Citrate Solution in the Prevention of Peritoneal Adhesions, Ann. Surg. **59**:101, 1914.

2. Sweet, J. E.; Chaney, R. H., and Willson, H. L.: Prevention of Postoperative Adhesions in the Peritoneal Cavity, Ann. Surg. **61**:297, 1915.

3. Kubota, T.: Peritoneal Adhesions, Japan Med. World **2**:226, 1922.

4. (*a*) Lehman, E. P., and Boys, F.: Heparin in the Prevention of Peritoneal Adhesions: Report of Progress, Ann. Surg. **112**:969, 1940; (*b*) The Prevention of Peritoneal Adhesions with Heparin: An Experimental Study, ibid. **111**:427, 1940; (*c*) Clinical Use of Heparin in the Peritoneum in the Prevention of Adhesions: Report of Fourteen Cases, Arch. Surg. **43**:933 (Dec.) 1941. (*d*) Boys, F.: Prophylaxis of Peritoneal Adhesions, Surgery **11**:118, 1942.

clinical data were presented on the effectiveness of the therapy in the other 13 cases.

The following experiments in rats are reported because they are at variance with the tenor of the results reported by Lehman and Boys in dogs and rabbits.

METHODS

The animals chosen for this study were albino rats (Mus norvegicus albinus) of the Wistar colony which had been inbred for years to an almost pure strain. Their nutritional factors were also carefully standardized so that individual variations in this factor might not influence the results of the experiments.

Dosage of Heparin and Results

No. of Rats	Procedure *	Result
5	NaOH 3%, 0.05 cc. intraperitoneally Heparin, 0.05 cc. in 2 cc. sodium chloride solution ½ hr. after	All had adhesions on the 4th day
5	NaOH 3%, 0.05 cc. intraperitoneally Heparin, 0.05 cc. in 2 cc. sodium chloride solution ½ hr. later Heparin, 0.05 cc. in 2 cc. sodium chloride solution 5 hr. later	All had adhesions on the 3rd day
5	NaOH 3%, 0.05 cc. intraperitoneally Heparin, 0.1 cc. in 10 cc. sodium chloride solution ½ hr. later Heparin, 0.1 cc. in 10 cc. sodium chloride solution 5 hr. later Heparin, 0.1 cc. in 10 cc. sodium chloride solution 10 hr. later	One died of hemorrhage; 4 had adhesions on the 4th day
5	NaOH 3%, 0.05 cc. intraperitoneally Heparin, 0.2 cc. ½ hr. later Heparin, 0.2 cc. 5 hr. later Heparin, 0.2 cc. 10 hr. later	Three died of hemorrhage; 2 had adhesions on the 4th day
5	NaOH 3%, 0.05 cc. intraperitoneally Heparin, 0.2 cc. in 20 cc. sodium chloride solution ½ hr. later	All had adhesions on the 1st day
5	NaOH 3%, 0.05 cc. intraperitoneally Blood, 2 cc. with heparin 0.1 cc.	All had adhesions on the 4th day
2	Traumatized cecum at operation Heparin, 0.2 cc. in 10 cc. sodium chloride solution at time of operation Heparin, 0.2 cc. in 10 cc. sodium chloride solution 4 hr. after operation	Both had adhesions on the 1st day
3	Traumatized cecum at operation Heparin, 0.2 at time of operation Heparin, 0.2 cc. after 4 hr.	Two died of hemorrhage; 1 had adhesion on the 4th day

* 1 cc. heparin = 10 mg.

One chemical and one mechanical method for the production of adhesions were standardized. In the chemical method, 0.05 cc. of a 3 per cent solution of sodium hydroxide was injected intraperitoneally through a small needle. This produced adhesions in all of a control series of 30 rats, with only 1 death. In the mechanical method, laparotomy was done under sterile conditions and a portion of the cecum was crushed with a clamp. In the control series of 30 animals run for this experiment, all showed adhesion formation. However, subsequent experience indicates that mechanical injury of this type does not always produce adhesions.

Heparin in varying amounts was used in eight groups of experiments using 35 rats. When sodium hydroxide was used to produce the

adhesions, heparin was introduced intraperitoneally by injection. When mechanical trauma was used, the first dose of heparin was instilled directly over the crushed area at the time of operation. Subsequent doses were injected intraperitoneally.

RESULTS

The various dosage schedules and the results are shown in the table. As the amount of heparin was increased, fatalities due to hemorrhage increased.

CONCLUSIONS

Heparin did not prevent the formation of intraperitoneal adhesions in the rat under a variety of conditions, even though it prevented the coagulation of blood in the peritoneal cavity. This suggests that the usual blood coagulation mechanism may not be essential for the formation of intraperitoneal adhesions in the rat.

ETIOLOGIC SIGNIFICANCE OF EVENTRATION OF THE DIAPHRAGM

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ALTHOUGH eventration of the diaphragm has been recognized as an entity since Petit's [1] description in 1774, it has been considered a clinical and pathologic curiosity worthy of repeated description and review but of no real importance. Until Bisgard's [2] article in 1947, operative correction of the lesion had been reported in 6 patients, all adults. Bisgard, however, recognized the significance of the abnormality and performed an operative repair in an infant. Operative repair has subsequently been performed in children by State and by me.

Thoma [3] in 1882 suggested that the lesion of eventration of the diaphragm was a congenital one and presented several proofs of his contention which have gained validity in the intervening years; it is to these that I wish to add emphasis and reenforcement. Furthermore, if this condition is a congenital one, if it is or can be injurious to health and to normal development and if it can be corrected by an operative procedure of low mortality and morbidity, then it becomes important that it be recognized as early as possible in the child's life. Recognition is simple with roentgenographic study, and it is our plea that a roentgenologic study of the chest be made on all newborn infants.

ETIOLOGY

If eventration of the diaphragm is a congenital lesion, roentgenographic study of newborn infants should reveal all the cases. As a most potent argument for the congenital origin, we have been unable to find any cases in the literature in which a patient was found to have an eventration who previously had had normal diaphragmatic activity. We have, however, 1 patient in our series who was said to have had a normal diaphragm before an abdominal injury which produced a large abdominal spigelian hernia. This patient, however, never had had a

From the surgical service of the Guthrie Clinic.

1. Petit, J. L.: Traité des maladies chirurgicales, et des opérations qui leur conviennent, Paris, T.-F. Didot jeune, 1774, vol. 2, p. 226.

2. Bisgard, J.: Congenital Eventration of the Diaphragm, J. Thoracic Surg. **16**:484, 1947.

3. Thoma, R.: Cited by Bayne-Jones, S.: Arch. Int. Med. **17**:221 (Feb.) 1916.

roentgenographic examination of his chest before the traumatic experience. The only evidence of normal diaphragmatic activity was a preemployment physical examination in which the examining physician had noted no abnormalities. After recognition of the eventration, through a chance finding at a gastrointestinal study, the physical signs of the eventration were not marked, and only Hoover's sign (a flaring of the

Fig. 1.—Roentgenogram of a newborn infant with an eventration of the diaphragm. This was made before there was a complete understanding of the possibilities of an operative repair. Note the small amount of effective pulmonary tissue. This patient died, and autopsy revealed an eventration.

costal margin during inspiration) was noteworthy. (This case demonstrates the forensic importance of an understanding of the etiology.)

Thoma has given four criteria as the basis for the congenital origin: (1) the coincidence of frequency of eventration of the left side of the diaphragm with the complexity of the development of that organ; (2)

the occurrence of eventration in the fetus and the newborn; (3) its association with other congenital abnormalities, and (4) the usual absence of symptoms over long periods. All these criteria seem to have qualified validity.

Thoma's second criterion does not, on the surface, appear so generally true. From the reports in the literature, one would judge that eventration in the fetus and the infant is not common. Bayne-Jones,[4] in his collected series in 1916, found only three reports in 45 cases,

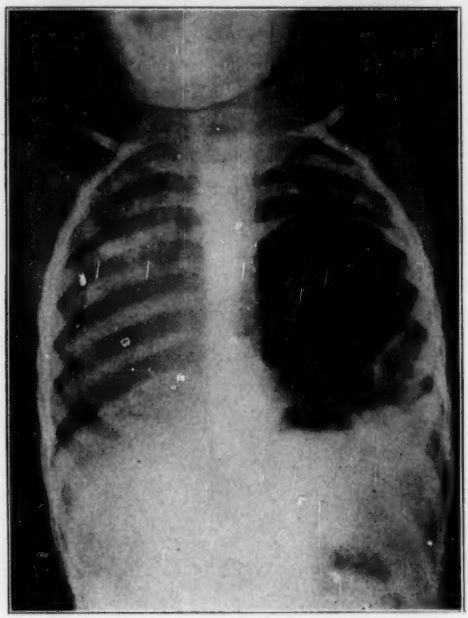

Fig. 2.—Preoperative roentgenogram of a surgically corrected eventration of the diaphragm. Note the shift of the heart to the right and the large gastric air shadow in the chest.

involving a fetus, a newborn baby 1 day old and an infant of 3 months. Bisgard found only 17 cases reported in the literature, including his own. I agree with him, however, in his remark that probably there are many unreported cases and that some of the deaths attributed to other causes of cyanosis and dyspnea have really resulted from eventration.

4. Bayne-Jones, S.: Eventration of the Diaphragm with Report of a Case of Right Sided Eventration, Arch. Int. Med. **17**:221 (Feb.) 1916.

Among the 6 cases observed in our clinic 1 child died with such symptoms, a second child was operated on and the other 4 patients were adults.

Furthermore, the anatomic studies reported by Bayne-Jones reveal that in cases of eventration the diaphragm is not a normal muscular organ. He found the pleural and peritoneal reflections to be normal and complete, while between them there appeared an aponeurotic sheet. In some cases there were remnants of muscle tissue in various locations.

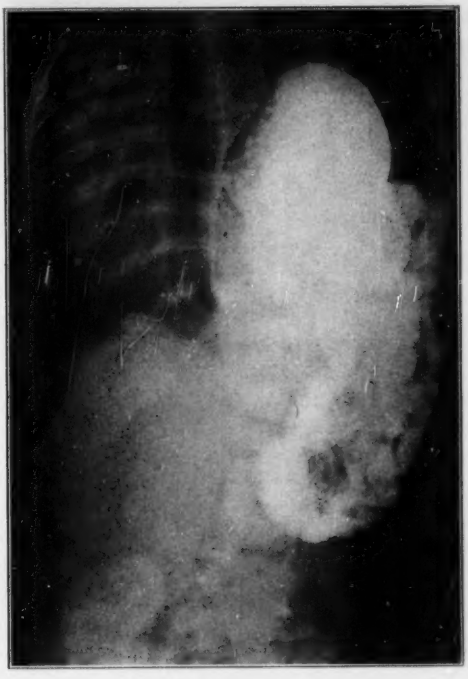

Fig. 3.—The same patient as illustrated in figure 2. Barium has been ingested. The major portion of the stomach and a portion of the small bowel is in the left side of the chest. The diaphragm, however, is intact.

Such muscle tissue, while sparse in amount, was morphologically normal and was not atrophic, as one would expect it to be in an acquired lesion.

Congenital muscular aplasias are not infrequent. They are discussed under a wide variety of names, usually called either arthrogryposis multiplex congenita, myodystrophia foetalis deformans, myophagism congenita or a host of other titles. Furthermore, although this condition is a

multistatic one, Max Bohm [5] has suggested that a monostatic form may be the cause of congenital clubfoot and Badgley [6] has intimated a similar etiology for congenital dislocation of the hip. Peculiarly enough, in human beings the diaphragm is usually, if not invariably, spared in arthrogryposis multiplex congenita. Roberts,[7] however, has found that in cases of arthrogryposis in sheep similar to that in human beings the diaphragm often consisted of a fibrous sheet and this accounted for

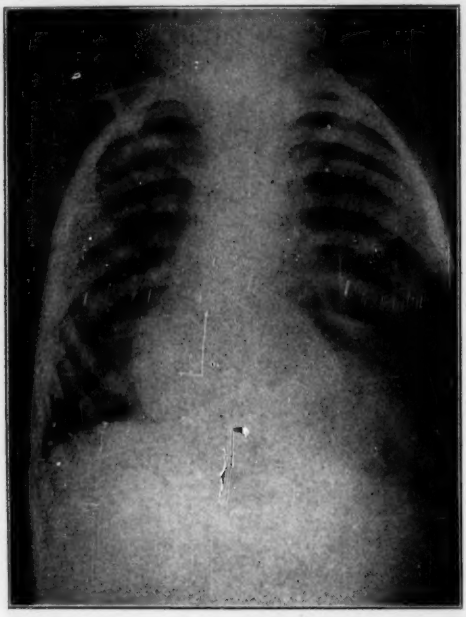

Fig. 4.—Postoperative roentgenogram of the patient seen in figures 2 and 3. Note the return of the heart to the left side of the chest and the areation of the lungs.

respiratory failure and death at birth. Moreover, the sections of the muscles of these sheep revealed a fat replacement of the muscular tissue

5. Bohm, M.: The Embryologic Origin of Club-Foot, J. Bone & Joint Surg. **11**:229, 1929.

6. Badgley, C. E.: Correlation of Clinical and Anatomical Facts Leading to a Conception of the Etiology of Congenital Hip Dysplasias, J. Bone & Joint Surg. **25**:503, 1943.

7. Roberts, J. A. F.: The Inheritance of a Lethal Muscle Contracture in Sheep, J. Genetics **21**:67, 1929.

similar to the anatomic findings in Benda's [8] case of eventration which he called "lipomatous pseudohypertrophy." In animals, as in human beings, there is no reaction of degeneration so that the condition is believed to be primarily a muscular aplasia rather than secondary to a nervous disturbance.

DIAGNOSIS

Assuming that the condition is a congenital one, how important is the diagnosis? As has been pointed out, it is probable that there are not too rarely cases of eventration which have been fatal to infants and children but which have remained unrecognized. Although the literature give as the most frequent symptom complex the gastrointestinal symptoms, I feel that the important symptoms are the respiratory ones. In the 3 cases in which surgical repair has been carried out in children, the

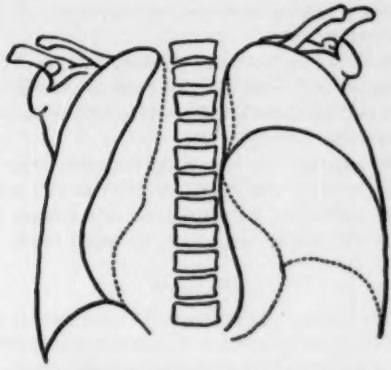

Fig. 5.—A diagram to illustrate the preoperative and postoperative contours in the roentgenogram of the chest in the patient operated on. The solid line indicates the preoperative sites of the diaphragmatic and mediastinal shadows. The broken line indicates the postoperative shadows.

outstanding symptoms have been dyspnea and cyanosis. In the 1 fatal case in our series (patient not surgically treated) the death was from respiratory causes. It is, therefore, important to differentiate eventration from the various cardiac abnormalities and from atelectasis. In cases of the former the differential diagnosis will be rendered easy by the position of the diaphragm and the cardiac findings. In differentiating the condition from atelectasis, one will note the displacement of the heart and mediastinum toward the unaffected side. The differentiation from diaphragmatic hernia is made on roentgenologic study. Biagard stated that it is important to visualize the entire diaphragm, which

8. Benda, cited by Bayne-Jones.[4]

visualization may necessitate oblique or lateral roentgenograms. Fluoroscopic study may be helpful. The diaphragm may be immobile, may have restricted normal motion or may display paradoxic movement.

THERAPY

It is difficult to discuss the therapy of this condition when there are so few reports of corrective attempts in the literature in any one's personal experience. From the meager data, however, there is the true suggestion that operative therapy is not only eminently successful but also not fraught with any great danger. Ten cases have been reported in the literature in which surgical treatment was given (Bisgard, 7; Hughes,[9] 1; State,[10] 1, and Beck,[11] 1). In this group there was 1 postoperative death; that fatality was in an adult. Of the other 6 adults, 4 were said to have complete relief of symptoms and 2 partial relief. In all the 3 cases involving children the convalescence was uneventful and the relief complete.

Interestingly, 2 of the 3 infants involved had the condition on the right side (Bisgard and State), in contrast to the usual occurrence, while our infant had it on the left side. In all these the cardiac position tended to return to the normal.

The operative approach has been both transthoracic and transabdominal, with equal success. The operative procedure is not difficult and consists in either a plication, an imbrication or a tenting and fixation of the diaphragm to the costal margin and the renal fascia.

SUMMARY

All the evidence points to the fact that eventration of the diaphragm is a congenital lesion. It appears that its main symptoms in the infant and child are those of respiratory embarrassment and cyanosis, in contrast to the milder adult gastrointestinal complaints. It is also probable that the condition is frequently missed and the symptoms ascribed to some other cause. It is becoming apparent that surgical correction of eventration can be safely and successfully performed.

The true incidence of eventration will not be discovered until extensive routine roentgenologic studies of newborn infants are carried out. Certainly, all children who display symptoms of cyanosis or dyspnea should be studied roentgenologically, with eventration of the diaphragm considered as one of the reparable congenital defects.

9. Hughes, F., in discussion on Bisgard.[7]

10. State, D.: The Surgical Correction of Congenital Eventration of the Diaphragm, Surgery **25**:461, 1949.

11. Beck, W. C., and Pixley, C.: Eventration of the Diaphragm in a Child: Report of a Case Successfully Treated Surgically, Guthrie Clin. Bull. **19**:151, 1950.

ANTERIOR (MEDIAN) PHARYNGOTOMY

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AND
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BETHESDA, MD.

WITH the development of endoscopic instruments, the pharynx, hypopharynx, base of the tongue, upper portion of esophagus and larynx have become reasonably accessible to exploration under direct vision without the necessity for a surgical incision. In the study and treatment of a majority of pathologic conditions in these areas, the endoscopic approach is adequate and furnishes valuable information. However, there are some conditions and circumstances in which a more adequate exposure is either advantageous or absolutely necessary. There have been a number of anatomic approaches to this problem, most of which involve the lateral pharyngeal wall.[1] These lateral approaches interrupt at least one important nerve when the opening in the pharynx is of any considerable length. An anterior approach does not destroy any major nerve or vessel and is an easier technical procedure.

PROCEDURE

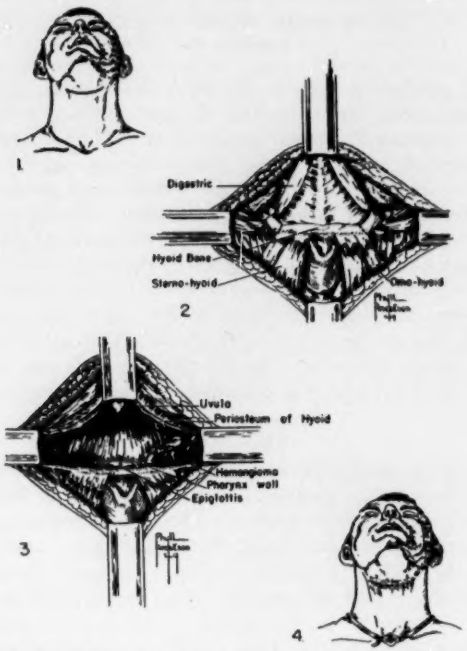
Any anterior approach must involve or be related to the hyoid bone. The hyoid bone can be removed completely, and neither disability nor annoying symptoms will be produced. Its central segment is excised almost routinely in the removal of thyroglossal cysts,[2] and it is often divided in the midline in total laryngectomy.[3] Hence, there has been sufficient evidence that the presence of an intact hyoid bone is not essential.

A general anesthesia is given either through a previously [illegible] structed low tracheostomy opening or through an intratracheal [illegible] Local anesthesia can be used if required. A transverse collar [illegible]

From the Department [illegible] Surgery and the [illegible] Memorial of the George [illegible] shington Univer[illegible] Schoo[illegible] [illegible] E. Warwick

1. Orton, H. B.: [illegible] Hyoid Bone, Ann. Otol., [illegible] Laryngotomy: Removal of Entire
2. Pemberton, [illegible] 51: 774, 1942.
Ann. Surg., 111: [illegible] Sinuses and Fistulae of the Thyroglossal Duct,
[illegible] E.: Cancer of the Larynx, in Nelson's Loose Leaf Surgery, [illegible] Thos. Nelson & Sons, 1947, p. 431.

is made overlying the hyoid bone (figure). This extends from the anterior border of the sternocleidomastoid muscle on the right to that on the left. Skin flaps are undermined in the plane just beneath the platysma muscle for a distance of 1 cm. above and below the incision. The hyoid bone is thus exposed. Periosteum is incised for a distance of at least 2 cm. on each side of the midline. This frees the central portion of hyoid bone from muscle attachments. The central segment is excised.



Anterior pharyngotomy: *1*, incision; *2*, exposure of hyoid bone; *3*, pharyngotomy; *4*, closure of wound.

The distal ends of the hyoid bone remain and are retracted laterally. The pharynx is entered through a transverse incision in the sulcus created by the removal of the central segment of the hyoid bone. This incision can be extended laterally to the tip of the hyoid on either side if required, without interference with or division of any major nerves. The superior laryngeal nerve lies just below the line of incision and is easily visualized. The hypoglossal nerve lies above the incision and is also easily visualized.

The whole posterior pharyngeal wall is now exposed from the level of the arytenoids to the uvula (figure). The latter can be elevated to expose the nasopharynx. The base of the tongue is readily accessible on the anterior-superior wall and the epiglottis on the anterior-inferior wall. All these structures and areas of the pharynx are accessible for any operative procedure which now will not differ greatly from an excision performed on the surface of the body. Excision of a tumor or the insertion of radium is easily accomplished.

After the extirpation or treatment is complete, the incision is easily closed. The base of the tongue is approximated to mucous membranes of the anterior surface of the epiglottis with interrupted sutures. This suture line is reenforced by suturing mylohyoid and geniohyoid muscles to the sternohyoid and thyrohyoid muscle. The platysma muscle and skin are approximated. No drainage is used.

Postoperative discomfort is minimal. Postoperative complications have been minor. There is a certain amount of edema of the pharyngeal structures and minimal dysphagia. The elective tracheostomy performed at the time of the original operation insures an adequate airway at all times. The wound in the neck heals primarily.

Postoperative care is not difficult. Penicillin is given for a minimum of seven days (300,000 units daily). A suction machine is placed at the bedside to assure patency of the tracheostomy at all times, and especially during the first forty-eight hours. Ingestion by mouth is not permitted for the first forty-eight hours. In most instances an intranasal feeding tube is inserted and nutrition and fluid balance maintained by this route. Parenteral administration of fluids can replace this but is not preferable. Fowler's position is preferred when the patient has fully reacted. Small amounts of codeine (½ grain [0.03 Gm.]) are the only sedation permitted, and the use of this is discouraged during the first twenty-four hours to prevent depression of the cough reflex.

The subsequent course is variable. Administration of antibiotics is discontinued in one week unless there is evidence of infection. Water by mouth is permitted at the end of forty-eight hours, and a liquid diet is begun as soon thereafter as it is evident that there is no regurgitation into the trachea. The diet is advanced as rapidly as can be tolerated. It is unusual for a full liquid or soft diet to be tolerated in less than one week. Ambulation is encouraged as early as the evening of the day of operation and increased as rapidly as possible. The tracheostomy tube is corked at intervals after forty-eight hours and is removed as soon as the patient has tolerated the corking of the tube for twenty-four consecutive hours (provided there is no obvious infection remaining in the neck). It is unusual to remove the tracheostomy tube in less than seven days. Sutures are removed in three to seven days as indicated.

INDICATIONS FOR OPERATION

1. *Excision of a Benign Tumor.*—CASE 1.—A 33 year old female nurse was admitted to the George Washington University Hospital on July 8, 1948.

History.—She first noted an ache in the left ear in February 1944. This was severe but not associated with fever or drainage. It subsided spontaneously but reappeared in May 1945. For this reason she sought medical advice. She had noted a slight loss of hearing in the left ear. She frequently aspirated food into her trachea and had occasional "choking" spells at night.

When she attended grade school she had been examined and found to have a "hemangioma" of the left lateral pharyngeal wall. She believed that she had had roentgen ray treatment at that time, but this could not be verified. Later, when in training, she sought aid for this condition and was told not to accept therapy unless the lesion grew in size. She believes the lesion grew slowly over the years.

When examined by a radiologist in May 1945, she was found to have an extensive, irregular, purplish lesion of the left lateral pharyngeal wall "filling the entire left tonsillar fossa." A diagnosis of cavernous hemangioma was made, and roentgen ray therapy was given to the left tonsillar area with the use of an intraoral cone. Treatment consisted of 500 roentgens daily for a total of 2,500 r, using 120 kilovolts and 1 mm. aluminum filter. Size of fields and target skin distance were not given. She had relief of otalgia at once. A "50 per cent reduction" in size was recorded.

In May 1948 she returned because of recurrence of earache and bleeding from the left nostril. She was having increasing difficulty in swallowing and occasional choking spells. Examination at that time by another radiologist disclosed a mass "almost exactly as described when seen in May 1945." It extended up to the opening of the eustachean tube in the nasopharynx. Because of an enlarged, tender, upper jugular node, the possibility of malignant change was suggested.

When seen in June 1948, the patient had an extensive cavernous hemangioma involving the entire left lateral pharyngeal wall from the eustachean tube orifice down to the pyriform sinus but not extending onto the soft palate, tongue or larynx. The largest of the visible veins was fully 1 cm. in diameter when distended. When distended, the mass protruded almost to the midline of the pharynx at the level of the tonsillar fossa. It did not involve the posterior pharyngeal wall. The lower limit of the lesion was checked by direct laryngoscopy. Surgical removal was advised and accepted.

Operation.—On July 9, 1948, with the patient under general anesthesia, a tracheostomy was performed below the level of the thyroid isthmus. A rubber cannula with an inflatable cuff was inserted through the tracheostomy opening. The cuff was distended and the tube connected to a closed anesthesia system. This prevented any aspiration from above and permitted accurate control of the airway at all times.

The lesion was exposed by means of an anterior pharyngotomy (figure). The hemangioma was excised, the excision beginning in the pyriform sinus and working upward. The entering veins were ligated and divided individually. While this was tedious, it was possible to do it with almost no loss of blood. The tumor extended from the left pyriform sinus up into the nasopharynx. After removal, it was possible to approximate the mucous membrane of the lateral pharyngeal wall over the raw area, except at the level of the tonsillar fossa. The operative incision was then closed in the usual manner.

The postoperative course was uneventful. A soft diet was tolerated on the third day. The tracheostomy tube was removed on the seventh day. The wound

healed by primary intention. The tracheostomy stoma closed spontaneously. When the patient was last seen in October 1948 the pharynx was entirely healed and normal in appearance. She had no symptoms relative to the site of the hemangioma or the operative procedure.

Microscopic examination of the removed tissue confirmed the clinical diagnosis of cavernous hemangioma.

2. *Excision of a Malignant Tumor.*—CASE 2.—A 54 year old man was admitted to Garfield Memorial Hospital on March 31, 1947.

Past History.—In September 1946 the patient experienced difficulty in swallowing and pain in the throat. At that time he had already been hospitalized in a tuberculosis sanitarium, having been under treatment for active tuberculosis for the previous five years. In December 1946 a mirror examination of the pharynx was made and a tumor discovered. A biopsy was made at the institution. A pathologic report of transitional cell carcinoma was returned.

In January 1947 the patient was seen by a radiologist. At that time there was "a sharply circumscribed tumor arising from the posterior pharyngeal wall." He received a total of 5,100 r to the right side of the neck with the use of kilovolt therapy through a 6 by 6 cm. field, at a 75 cm. target skin distance with 3 mm. of copper filter. Approximately 300 r was given daily. Treatment was complete in thirty-six days. There was some regression of the tumor. In March 1947 he was free of symptoms and swallowing with relative ease. However, on mirror examination it was found that the tumor persisted and measured at least 1.5 cm. in diameter.

He was seen in consultation at that time. On the posterior pharyngeal wall, at about the level of the upper end of the epiglottis and just to the right of the midline, there was a rounded smooth tumor 2.5 cm. in diameter. It was attached by a pedicle to the posterior pharyngeal wall. The pedicle measured 2 cm. in diameter. There were no palpably diseased nodes in either side of the neck.

At this time the man had active tuberculosis, with the organisms present in the sputum. The only other significant point in the history was that an abdominoperineal resection of the rectum had been performed for carcinoma in 1942.

Operation.—On March 31, 1947, with the patient under general anesthesia, a tracheostomy was performed below the level of the thyroid isthmus. A rubber cannula with an inflatable cuff was inserted through the tracheostomy opening. The cuff was distended and the tube connected to a closed anesthesia system.

The lesion was exposed by means of anterior pharyngotomy. In exposure, the hyoid bone was merely divided in the midline, and no portion of it was excised. When the pharynx was opened, the malignant tumor was found to lie on the posterior wall at the level of the hyoid bone. It was attached to the pharyngeal wall by a pedicle 2 cm. in diameter. There was no fixation to the vertebrae. It was possible to excise the lesion with a margin of 1.5 cm. on all sides of the pedicle. There was no evidence of infiltration into prevertebral fascia. The mucosa was undermined on each side of the incision and could be approximated in the midline with interrupted surgical gut sutures. The incision was closed in the usual manner.

The postoperative course in the hospital was uneventful. Within two weeks the patient was tolerating a soft diet, with no discomfort, and within three weeks the tracheostomy opening had closed spontaneously. However, on indirect laryngoscopy there was an area of necrosis on the posterior pharyngeal wall, the base of the tongue and in the sulcus between the tongue and the epiglottis. By May 19, 1947, the posterior pharyngeal wall was completely epithelized. However, a fistula had developed in the anterior region of the neck. The area of visible necrosis in the glossoepiglottic sulcus remained, and it was felt that the external fistula connected

with this area. Arrangements were made for a trial of streptomycin at the tuberculosis sanatorium, as it was felt this sinus might be related to the tuberculosis. The sputum still contained pathogenic organisms. However, the sinus tract did not close, and the induration around the sinus tract persisted under treatment.

In August 1947 he had one episode of bleeding into the pharynx. At this time severe pain in the right ear and dysphagia developed. This pain increased in severity. On Sept. 26, 1947, he was again hospitalized because of increasing pain in the right side of the neck. The sinus tract was considerably larger. It was apparent that the entire right ala of the thyroid cartilage had separated, was necrotic and served as a sequestrum. The necrotic thyroid cartilage was removed from the sinus tract, without anesthesia. On the following day the patient was given a general anesthesia through a tracheostomy tube, reinserted into its previous site. An incision was then made along the posterior border of the right sternomastoid muscle and the first four cervical nerves divided as they emerged from the cervical foramens. A lymph node, encountered in the course of this procedure, was removed and found to contain metastatic epidermoid carcinoma. Healing from this was uneventful, and pain was controlled. The patient was discharged to the tuberculosis sanatorium. Total laryngectomy, excision of the pharynx and dissection of the right side of the neck were considered, but in view of the active tuberculosis, the general physical condition and the previous irradiation, this was not deemed advisable. After his return to the sanatorium his condition became progressively worse, and he died in December 1947.

CASE 3.—W. L. E., a 28 year old Negro, was admitted to the United States Naval Hospital, Bethesda, Md., on April 10, 1947.

History.—The patient was considered to be a hypochondriac and to have cancerophobia. Two months prior to his entry, he had closely examined his oral cavity in the mirror. He noticed a small protrusion on the posterior pharyngeal wall, just over the free border of the tongue. He sought advice from a private physician and was referred to a hospital, where a biopsy was performed. A report of epidermoid carcinoma was returned. He was given daily roentgen treatments for two and one-half weeks and then referred, through the Veterans Bureau, to this hospital. The total irradiation dosage was estimated at approximately 6,000 r.

Examination.—On examination of the oral cavity the only pathologic changes noted were on the posterior pharyngeal wall. Here, at the level of the base of the tonsil, and extending downward for 1.5 cm., there was a rounded elevation 1.5 cm. in diameter. This was attached by a broad base to the posterior pharyngeal wall. It was not ulcerated but appeared friable. There were no palpably diseased nodes in the neck. The diagnosis of epidermoid carcinoma was confirmed by biopsy.

Operation.—With the patient under general anesthesia a tracheostomy was performed below the level of the thyroid isthmus. A rubber cannula with an inflatable cuff was inserted through the tracheostomy opening. The cuff was distended and the tube connected to a closed anesthesia system.

The lesion was exposed by means of an anterior pharyngotomy. It was not considered necessary to divide or remove the hyoid bone. The incision was made along its upper border. This did limit the exposure. The tumor was visible on the posterior pharyngeal wall. It was excised, a 1 cm. margin of mucous membrane being allowed on all sides of the base. There was no evidence of invasion of the prevertebral fascia. The mucosa was undermined on each side, and the cut edges were approximated in the midline with interrupted sutures. The incision was closed in the usual manner.

The postoperative course was uneventful. A soft diet was tolerated on the fifth day. The tracheostomy tube was removed on the seventh day. The wound healed by primary intention. The tracheostomy stoma closed spontaneously. When the patient was last seen in November 1948, the pharynx was entirely healed and normal in appearance. He was asymptomatic.

CASE 4.—S. M. Y., a 37 year old white man, was admitted to the United States Naval Hospital, Bethesda, Md., on June 16, 1948.

Past History.—An annoying sensation of fulness in the throat and mild tenderness on palpation above Adam's apple caused the patient to apply for treatment in the outpatient department.

Examination.—Mirror examination revealed a reddish pea-sized, well circumscribed lesion on the glottic surface of the epiglottis in the upper left quadrant. There was no fixation of the epiglottis and no surrounding edema or infiltration. Biopsy of the lesion on direct laryngoscopy revealed an epidermoid carcinoma, grade II.

Operation.—On July 1, 1948, a low tracheostomy was performed with the patient under local anesthesia. General anesthesia was then induced, a rubber cannula with an inflatable cuff being inserted through the tracheostomy opening.

The epiglottis was exposed by means of anterior pharyngotomy. The central portion of the hyoid bone was removed. The tumor was visualized involving the middle third of the left side of the epiglottis. The entire lesion was 1 cm. in diameter, with a broad base. The epiglottis was resected, only a short stump being left. The mucosa was easily approximated. No drainage was used.

Liquids were given on the second postoperative day, and the feeding tube was discarded on the fourth day. The tracheostomy cannula was retained until the tenth postoperative day because of the patient's apprehension. The tube had been occluded with a cork for several days before removal. Complete healing of the wound had occurred at the time of decannulization.

Microscopic studies of the specimen revealed an amelanotic malignant melanoma.

Follow-up examinations revealed no difficulty with swallowing and no evidence of recurrence of the lesion six months after operation.

3. *Insertion of Radium Needles.*—CASE 5.—E. S. S., a 61 year old white man, was admitted to the United States Naval Hospital, Bethesda, Md., on Nov. 12, 1948.

Past History.—He had noticed dysphagia and discomfort in both ears for about five months prior to his entry, accompanied with a productive cough and occasional hemoptysis. The dysphagia became progressive, some dyspnea developed and he consulted a physician, who referred him to the hospital. He also gave a history of pulmonary tuberculosis in 1945, with no recent activity.

Examination.—On examination of the oral cavity, pharynx and larynx, it was apparent that there was considerable edema of the epiglottis, the aryepiglottic folds, the ventricles and the lateral pharyngeal wall. It was impossible to see the cords. Protruding from the posterior pharyngeal wall was an ulcerated mass extending completely across the pharynx. Biopsy of this mass showed epidermoid carcinoma. There were no diseased neck nodes palpable in either side of the neck.

In view of the poor prognosis for this type of lesion following the usual form of irradiation therapy, it was decided that it should be explored. If technically resectable, it should be removed. If not resectable, it would be possible to insert interstitial radium needles which would later be supplemented with external radiation.

Operation.—A preliminary low tracheostomy was performed because of moderate respiratory embarrassment. With the patient under general anesthesia, a rubber cannula with an inflatable cuff was inserted through the tracheostomy opening. The cuff was distended and the tube connected to a closed anesthesia system.

The pharynx was opened by means of anterior pharyngotomy. The midportion of the hyoid bone was removed. It was apparent that the lesion occupied the whole of the posterior wall of the pharynx, extending upward from the level of the arytenoids for a distance of 3 cm. and downward for a distance of 1 cm. The lesion was ulcerated and extended through the prevertebral fascia into the bodies of the cervical vertebrae. The lesion was fixed to the fascia and to the anterior bodies of the vertebrae. There was, however, no exposed bone in the base of the ulceration. Removal of the lesion would have been impossible without removal of the bodies of the vertebrae. For this reason it was decided that interstitial radiation should be utilized.

As preparation for insertion of radium, a pharyngostome was created by suturing the mucous membrane of the pharynx to the skin. Twenty-four hours later, with the patient under topical anesthesia, six 3 mg. radium needles containing 1 mg. of radium per centimeter of active length were inserted in a uniplanar pattern throughout the lesion. These were allowed to remain until a 5,000 gamma roentgen tumor dose had been delivered.

After the radium needles had been removed, the pharyngostome was allowed to remain open. An attempt was made to give external irradiation through the pharyngostome, but this was not feasible. Treatment was then given through lateral fields until a total tumor dose of 9,000 roentgen rays had been delivered.

The pharyngostome remained opened, and no attempt was made to close it. The course was slowly progressive, and the patient died on June 13, 1949, after massive hemorrhage from the base of the lesion.

4. *Determination of Site or Operability of a Pharyngeal Lesion.*—CASE 6.—A 54 year old white man was admitted to the George Washington University Hospital in July 1948.

Past History.—In May 1948 he had noted hoarseness and a sense of soreness in the lower portion of the throat. Almost immediately thereafter he was conscious of a lump in the upper portion of the right side of the neck. He consulted a physician one week prior to his entry. He was referred to an otolaryngologist, who attempted a direct laryngoscopy. Because of the man's physical stature and his inability to open his mouth to any appreciable extent, it was impossible to do a direct laryngoscopy and establish a diagnosis. He was referred for opinion and therapy.

His past history was significant in that ten years previously he had had a "right cerebral hemorrhage," from which there had been complete recovery.

On mirror examination of the pharynx and larynx, it was impossible to visualize any true lesion. There was considerable edema of the epiglottis, the right aryepiglottic fold, the arytenoids, the right ventricle and a portion of the left ventricle. There was an enlarged node in the right upper cervical region measuring 3 cm. in diameter. A tentative diagnosis of carcinoma of the extrinsic larynx with metastasis to the right side of the neck was made.

He was admitted to the hospital on two occasions, and two attempts were made to obtain material for a biopsy by direct laryngoscopy. The last attempt was made with the patient under general anesthesia. It was impossible to overcome a partial trismus, and a positive biopsy was not obtained. In June 1948 a severe attack of dyspnea developed, and he was readmitted to the hospital. An emergency tracheostomy was done while he was under local anesthesia. The tracheostomy tube was inserted below the level of the thyroid isthmus.

The tentative diagnosis of carcinoma of the extrinsic larynx with metastasis to the right cervical nodes was still entertained. It was decided that exposure of the laryngeal structures was impossible by the oral route but that definitive therapy would depend entirely on such exposure. For this reason an anterior pharyngotomy was used to expose the area and establish an exact anatomic and histologic diagnosis.

Operation.—In July 1948 a rubber cannula with an inflatable cuff was inserted through the tracheostomy opening. The cuff was distended and the tube connected to a closed anesthesia system. General anesthesia was given.

The pharynx was exposed by anterior pharygotomy. The midportion of the hyoid bone was removed. It was apparent that the lesion was not in the larynx but in the right pyriform fossa, extending downward for 0.5 cm. into the upper region of the esophagus. A biopsy of material from this area was made, and the report was returned that a frozen section showed epidermoid carcinoma. As soon as the diagnosis had been established, the operation was extended and complete removal of the larynx, lateral pharyngeal wall and upper portion of the esophagus combined with complete dissection of the right side of the neck was carried out. The entire operation was done in continuity. It was possible to reestablish the continuity of the pharynx and esophagus by utilizing mucous membrane from the left pyriform fossa.

The postoperative course was relatively uneventful. Tube feedings were continued up to the seventh day. Some necrosis of the anterior skin flap in the right side of the neck developed, and it was necessary to excise this necrotic area and close the defect by elevation of a flap ten days after the original operation. Healing was entirely uneventful. The patient was discharged from the hospital at the end of three weeks. When last seen in July 1949 he was asymptomatic as far as the operative site was concerned.

Case 5, originally cited as an instance of the use of anterior pharyngotomy for insertion of radium, also illustrates the use of this procedure to determine the extent of the lesion before definite decision is made concerning the best mode of therapy.

COMMENT

Pharyngotomy is a useful procedure in the therapy of cancers of the oral cavity. The indications for the procedure are (1) excision of a benign or malignant tumor of the pharyngeal wall, (2) implantation of interstitial radium into a nonresectable lesion of the pharynx and (3) establishment of an accurate anatomic diagnosis when this cannot be done by means of endoscopy.

A fourth indication might be as a preliminary step in the excision of certain tumors of the base of the tongue. However, the pharyngotomy is then merely a part of a definite operative procedure and is better considered in a discussion of surgery of the tongue.

During our development of this procedure, Réthi [4] published an article on the same approach. In his method the hyoid bone was carefully preserved after it was divided and subsequently approximated in the midline. In our experience this seems unnecessary, as there have

4. Réthi, A.: A New Method of Transverse Pharyngotomy, J. Laryng. & Otol. **62**:440, 1948.

been no adverse symptoms relative to loss of the hyoid. Our exposure has been better after removal of at least the central segment, and the procedure is simpler.

Pharyngotomy can be done by other approaches. Orton [1] has developed the lateral approach, which is excellent for certain tumors of lateral pharyngeal wall. Trotter [5] used a modification of this lateral approach, which is also excellent for some tumors of the lateral pharyngeal wall. However, the exposure of tumors of the posterior pharyngeal wall is better if the anterior approach is used. Likewise, if the lateral pharyngeal tumor is extensive and extends to the posterior and anterior wall, the anterior approach is preferable as the tumor can be exposed without cutting through diseased tissue.

It has been our practice to combine the removal of the primary cancer with removal of the regional nodes en bloc, at least whenever there is probable metatasis to regional nodes. When this procedure is being considered in the treatment of a pharyngeal or laryngeal cancer of borderline operability, the use of anterior pharyngotomy as the preliminary step in the operation is most useful. When the pharyngotomy has been completed, the operability can be established unequivocally. At the same time, it is easy to extend the incisions onto either side of the neck and complete the dissection without unnecessarily jeopardizing the viability of the skin flaps and without cutting across either the gross tumor or the intervening lymphatic vessels.

The only possible contraindications which were apparent to us are illustrated in case 2. The patient had received heavy local roentgen irradiation prior to the surgical procedure, and he also had active tuberculosis. Whether either of these conditions alone would have been sufficient to produce the necrosis of the thyroid cartilage and the sinus tract in the neck is open to question. However, in view of his subsequent course, it might have been better to have removed the hyoid bone completely and to have protected the thyroid cartilages by not exposing them in any circumstance. It is possible that if this had been done the original area of necrosis in the glossoepiglottic sulcus would not have developed.

SUMMARY

The procedure of anterior pharyngotomy has been described. The indications for the operation are outlined, and illustrative case reports are given. The procedure is a useful diagnostic and therapeutic approach to disease in the pharyngeal area. Morbidity and complications are minimal.

5. Trotter, W.: Method of Lateral Pharyngotomy for Exposure of Large Growths in Epilaryngeal Region, J. Laryng., Rhin. & Otol. **35**:289, 1920.

INTERNAL HERNIA

Review of Literature and Report of an Obstructed Transmesenteric Hernia and of an Intersigmoid Hernia

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HARVEY B. STONE,[1] referring specifically to abdominal hernias, tersely stated: "The *one essential condition* for the existence of hernia is a defect in the containing and restraining structures of the abdomen which permits its contents to protrude beyond their normal limits." Transmesenteric hernias, not possessing a hernial sac but consisting merely of a protrusion of a loop of bowel or omentum through a hole in the mesentery, like most other internal hernias, barely fulfil the one essential condition mentioned.

VARIETIES

There are many varieties of abdominal hernia. The containing structures of the abdomen comprise the most common varieties, including direct and indirect inguinal, femoral, umbilical, ventral, diaphragmatic, lumbar, obturator, sciatic and perineal hernias. The restraining structures of the abdomen comprise most of the varieties of internal hernia, such as paraduodenal, cecal and intersigmoid hernias, hernia into the foramen of Winslow and hernias through defects or holes in the mesocolon (transmesocolic hernia), the omentum (transepiploic hernia), the gastrohepatic ligament (gastrohepatic hernia), the falciform ligament of the liver,[2] the broad ligaments of the uterus [3] or the mesentery of the small intestine (transmesenteric hernia; figs. 1 and 2). This discussion deals particularly with transmesenteric hernias, but much of it applies with equal force to the "aperture" or defect type of internal hernia in general.

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1. Stone, H. B., cited by Lewis, D.: Practice of Surgery, Hagerstown, Md., W. F. Prior Company, Inc., 1948, vol. 7, chap. 9, p. 1.

2. Gaster, J.: Internal Hernia with Strangulation of Bowel Due to a Defect in the Falciform Ligament, Ann. Surg. **128**:248, 1948.

3. Goode, T. V., and Newbern, W. R.: Intestinal Obstruction Associated with Defects in Broad Ligaments of Uterus: Review of Literature and Case Report, Am. J. Surg. **65**:127, 1944.

INCIDENCE

Transmesenteric hernias are extremely rare, yet Cutler and Scott [4] have succeeded in collecting 50 cases, involving 29 males and 21 females, the youngest being 4 days old and the oldest 73 years, with a fairly even distribution among all age groups. Hansmann and Morton [5] in 1939 classified 467 reported cases of intra-abdominal hernia

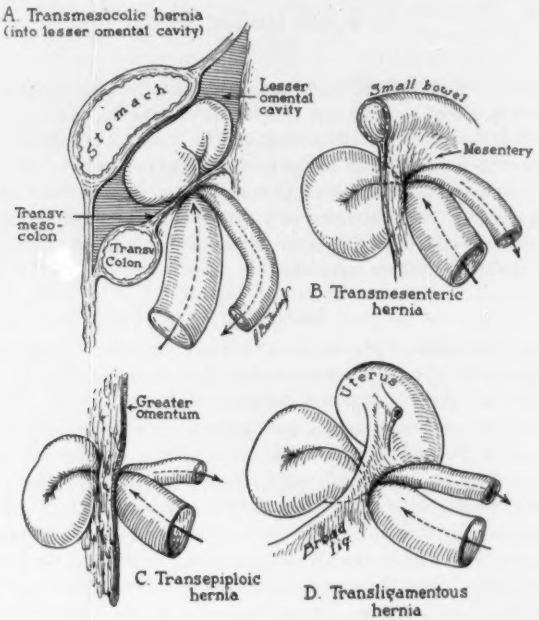

Fig. 1.—*A*, transmesocolic hernia. The intestine passes posterior to the greater omentum and transverse colon, through a defect in the transverse mesocolon, into the lesser omental cavity. *B*, transmesenteric hernia. The intestine passes through a defect in the mesentery of the small intestine. *C*, transepiploic hernia. The intestine passes through a defect in the greater omentum. *D*, transligamentous hernia. The intestine passes through a defect in the broad ligament.

according to the site of the hernial orifice. Internal hernias involving the paraduodenal fossae were by far the most common, constituting

4. Cutler, G. D., and Scott, H. W.: Transmesenteric Hernia, Surg., Gynec. & Obst. **79**:509, 1944.

5. Hansmann, G. H., and Morton, S. A.: Intra-Abdominal Hernia: Report of a Case and Review of the Literature, Arch. Surg. **39**:973 (Dec.) 1939.

53 per cent; hernias involving a defect in the mesogastrium,[6] mesentery or mescolon, when grouped together, aggregated 144, or 30.8 per cent, while those involving defects in the mesentery of the small intestine alone amounted to 52, or 11 per cent. Moses [7] in 1946 found 5 cases of internal hernia (4.2 per cent) in 118 cases of acute intestinal obstruction. McIver [8] in 1933 found 3 cases of internal hernia of all types in

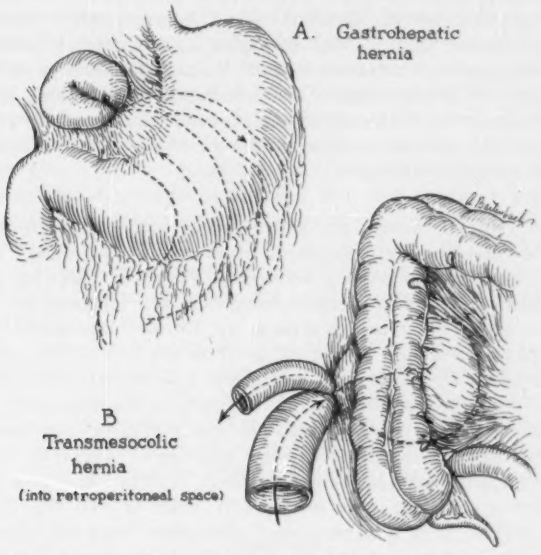

Fig. 2.—*A*, gastrohepatic hernia. The intestine passes into the lesser omental cavity through a defect in either the transverse mesocolon (as here depicted) or the gastrocolic ligament and returns to the general abdominal cavity through a defect in the gastrohepatic ligament. *B*, transmesocolic hernia. The intestine passes through a defect in the lateral (or medial) peritoneal reflection of the colon into the retroperitoneal space.

6. Mesogastrium is an embryologic term referring to the dorsal and ventral mesenteries, whence the falciform ligament, the gastrohepatic ligament, the gastrocolic ligament and the greater omentum are developed. (Jordon, H. E., and Kindred, J. E.: Textbook of Embryology, New York, D. Appleton-Century Company, 1942, pp. 256-262. Prentiss, C. W., and Arey, L. B.: A Laboratory Manual and Textbook of Embryology, Philadelphia, W. B. Saunders Company, 1922, p. 180.

7. Moses, W. R.: Acute Obstruction of Small Intestine: One Hundred and Eighteen Cases, New England J. Med. **234**:78, 1946.

8. McIver, M. A.: Acute Intestinal Obstruction, Am. J. Surg. **19**:177 and 581, 1933.

335 cases of acute intestinal obstruction in the Massachusetts General Hospital, an incidence of 0.9 per cent, and cited Broun and Wartmann as having found 8 examples in 379 cases. Thus, transmesenteric hernia has been variously reported as the cause of 1 in every 101 to 218 cases of acute intestinal obstruction and of 1 in every 9 cases of internal hernia.

The preexistence of a defect in the mesentery is a prerequisite to transmesenteric hernia. Mitchell [9] found three mesenteric defects in 1,000 necropsies, all in the ileocecal region, while Watson [10] found three in 1,600 autopsies, and Meade [11] cited Whitnal and Simpson as having found two in the examination of 50 bodies in the dissecting room at McGill University. The mesenteric aperture, usually small, averages 2 to 3 cm. in diameter and is usually circular or oval shaped, with smooth peritonealized edges.[4]

ETIOLOGY

The cause of mesenteric defects is not conclusively proved. In fact, they may possibly be produced in several ways. Dolton [12] quoted Prutz (1907) as enumerating five origins: traumatic, following chronic inflammatory processes, operative, congenital and spontaneous. There is little support for trauma as a cause, yet Brown [13] described a patient operated on three days after a fall in whom the rent in the mesentery was slitlike, with rough edges resembling a laceration, and there was "about one-half liter of blood tinged fluid" in the peritoneal cavity. In this case there is strong evidence that the cause was traumatic. Inflammation as a cause has few case histories to support it. Operative injury, with resulting mesenteric defect, or failure to oppose mesenteric leaves accurately after intestinal resection is well founded as a cause, just as it is well recognized after other intra-abdominal procedures, e. g., hernia through the mesocolic defect after posterior gastrojejunostomy. Atavistic regression of the mesentery is favored by some writers, notably Federschmidt (1920),[14] who stated that "while there is a regression of the ventral mesentery in man, in other mammals the dorsal mesentery is also involved" and that "congenital defects in the mesentery represent a partial regression of the dorsal mesentery in the human being." Ménégaux [15] (1934) thought that "fenestration

9. Mitchell, L. J.: Strangulated Internal Hernia Through a Mesenteric Hole, Ann. Surg. **30**:505, 1899.

10. Watson, L. F.: Hernia, St. Louis, C. V. Mosby Company, 1938, p. 420.

11. Meade, H. S.: Hernias Through Mesentery of Ileocecal Junction, Irish J. M. Sc., 1942, pp. 103-108.

12. Dolton, E. G.: Mesenteric Defects, Brit. J. Surg. **31**:275, 1944.

13. Brown, H. P., Jr.: Intraperitoneal Hernia of the Ileum Through a Rent in the Mesentery, Ann. Surg. **72**:516, 1920.

14. Federschmidt, cited by Dolton.[12]

15. Ménégaux, cited by Dolton.[12]

occurred during the developmental enlargement of an inadequately vascularized area." Dolton added that, in addition, "ileocecal mesentery, due to the descent of the cecum, undergoes considerable and rapid lengthening in fetal life." The goose commonly has multiple fenestrations in the mesentery, and Long [16] reported such openings in the ileal mesentery in a human being. The theory most widely supported and with the greatest weight of evidence is the developmental theory, which has in recent times more or less fused with the congenital theory. When two epithelial layers are opposed, with a deficient intervening supporting stroma of connective tissue, coalescence inevitably takes place, with the development of a space or defect. Macklin [17] found this to be true in the alveolar spaces of the lungs. Treves [18] described such conditions in the mesentery of the ileocecal region, stating that "the mesentery in this region is poorly supported and contains neither fat, lymph nodes, nor visible blood vessels," and it was here that he found defects in cadavers. Conceivably, similar conditions could occur in any other segment of the mesentery of the small intestine, though admittedly with less frequency, and thus account for a defect. If such conditions were acquired, and not congenital, the resulting defect would be regarded as spontaneous in origin.

The mechanism of production of a transmesenteric hernia is that a portion or loop of bowel accidentally protrudes through the preexisting defect. Then the propulsive effect of peristalsis forces more loops through, or the distention with gas of the protruded loop forms a gas trap which draws more bowel through the aperture until incarceration occurs. This gas trap mechanism has been demonstrated experimentally by Gatch, Trusler and Ayers.[19]

SYMPTOMS

As with internal hernia in general, there are no symptoms characteristic of transmesenteric hernia. Uncomplicated and, frequently, incarcerated (i. e., irreducible) hernias may be asymptomatic. Obstruction or strangulation frequently ushers in the first symptoms, and even here the symptoms and findings may lead only to a diagnosis of intestinal obstruction or strangulation without giving a clue to the cause. Nevertheless, since gangrene occurs in 62 per cent of the cases, as early

16. Long, E. R.: Acute Intestinal Obstruction in a New-Born Infant from Hernia of the Lower Ileum Through a Congenital Mesenteric Opening, Tr. Chicago Path. Soc. **12**:335, 1927.

17. Macklin, C. C.: Alveolar Pores in the Lungs of Man and Other Mammals, Anat. Rec. (supp.) **61**:33, 1935.

18. Treves, F.: Anatomy of the Intestinal Canal and Peritoneum in Man, London, H. K. Lewis & Co., Ltd., 1885.

19. Gatch, W. D.; Trusler, H. M., and Ayers, K. D.: Effects of Gaseous Distention on Obstructed Bowel: Incarceration of Intestine by Gas Traps, Arch. Surg. **14**:1215 (June) 1927.

as six hours and as late as eleven days after the onset of symptoms, there is a great need for the early diagnosis of obstructed internal hernia, so that definitive treatment may be more rapidly instituted. While acute irreversible intestinal obstruction is most frequently the presenting picture, there is a small group of patients who have symptoms preceding the onset of the acute obstructive phase. R. Smith [20] reported a case in which there were four attacks of abdominal pain with vomiting, each attack lasting several days; Tanner,[21] one in which there were two attacks of ulcer-like symptoms at four year intervals; Cullen, cited by Dolton, one in which there were four or five attacks of abdominal pain relieved by vomiting; King, again cited by Dolton, a case in which there was pain in the right iliac fossa for three months; A. M. Smith, also cited by Dolton, one in which there were two weeks of intermittent abdominal pain, and D. O. Ferris [22] still another in which there were four attacks of lower abdominal pain in one year. The first case herewith reported is one which for three weeks prior to strangulation presented the symptoms of abdominal pains, intermittent in type, gas, belching and abdominal distention without relation to the intake of food. Very probably the cause of the disturbance was repeated, transient periods of partial obstruction with little or no strangulation. Possibly it could have been demonstrated roentgenographically. In the second case reported there were two separate attacks of acute intestinal obstruction with spontaneous recovery, which illustrated in a most classic manner this valuable clue to the diagnosis of obstructed internal hernia.

DIAGNOSIS

Acute intestinal obstruction is nearly always the diagnosis made in any case of internal hernia. In order of frequency, according to Gatch,[23] the causes of intestinal obstruction are strangulated external hernia, 44 per cent; bands and adhesions, 30 per cent; neoplasm, 10 per cent; intussusception, 5 per cent; volvulus, 4 per cent; mesenteric thrombosis, 3 per cent; gallstones and other foreign bodies, 2 per cent; internal hernia, 0.9 per cent; Meckel's diverticulum, 0.6 per cent, and congenital anomalies, 0.6 per cent. With seven other more frequent causes of obstruction, it is obviously difficult from a statistical point of view alone to arrive at a specific diagnosis. Internal hernia

20. Smith, R.: Hernia of Ileum Through Hole in Transverse Mesocolon: Case with Symptoms and Radiologic Appearances Simulating Meckel's Diverticulum, Brit. J. Surg. **33**:187, 1945.

21. Tanner, N. C.: Hernia Traversing the Lesser Sac, Brit. J. Surg. **33**:184, 1945.

22. A case observed by the author on the surgical service of Dr. D. O. Ferris, Mayo Clinic, in August 1948.

23. Gatch, W. D., in Lewis, D.: Practice of Surgery, Hagerstown, Md., W. F. Prior Company, Inc., 1948, vol. 7, chap. 7, p. 21.

may be suspected if there are repeated attacks of abdominal pain, belching, distention, hyperperistalsis and vomiting. Intestinal obstruction may be presumed to be present if there are repeated attacks of cramplike abdominal pain, distention, hyperperistalsis observed on auscultation, vomiting, localized abdominal tenderness, constipation or short bouts of diarrhea, gas, belching, bloating and distress after eating, and it most certainly is present if there are, in addition, a silent abdomen on auscultation, increase of the erythrocyte and leukocyte counts and of the hematocrit value, a decreased value for plasma chlorides, increased nonprotein nitrogen, a high specific gravity of the urine and roentgenographic visualization of fluid levels and stepladder arrangement of the small intestine. Prompt surgical exploration in the first phase should reduce the relatively high incidence of late intestinal obstruction with strangulation and gangrene so frequently encountered in cases of intra-abdominal hernia.

TREATMENT

Treatment is directed at reduction of the herniated loop, slitting the margin of the defect, if necessary, if the loop is viable. If the herniated loop is nonviable, resection of all the gangrenous bowel is the only course open to the surgeon.

According to Cutler and Scott (1944), resection by the Mikulicz method was attended by a lower mortality than that by primary anastomosis.

MORTALITY

Cutler and Scott found with obstructed transmesenteric hernias that reduction (19 cases) and resection (22 cases) were about equally divided in their series. Their study revealed an over-all mortality of 38 per cent, 15.7 per cent in 19 cases in which reduction without resection was possible, 31.8 per cent in 22 cases in which resection was done, with a 20.0 per cent mortality in 5 cases when the Mikulicz type of resection was done, and a 35.2 per cent mortality in 17 cases in which resection with primary anastomosis was done. The mortality of acute intestinal obstruction from all causes has been cited by Smith and Van Beuren [24] (1939) as 23.8 per cent, by Dennis [25] (1943) as 18 to 20 per cent, by Dolton (1944) as 33 per cent and by Moses (1946) as 8 to 24 per cent. (Statistics collected since the advent of antibiotics and chemotherapy should show a lowered mortality.) Thus, while the

24. Smith, B. C., and Van Beuren, F. T.: Acute Ileus: Analysis of One Hundred and Thirty Cases Operated Upon at Presbyterian Hospital, New York City, from 1936 to 1939, with Use of Miller-Abbott Tube in 1938 and 1939, Ann. Surg. **117**:427, 1943.

25. Dennis, C., and Brown, S. P.: Treatment of Small Bowel Obstruction: Procedure Used at University of Minnesota Hospitals, Surgery **13**:94, 1943.

mortality for obstructed internal hernia is higher than that for acute intestinal obstruction in general, it is lower than average when the Mikulicz type of resection is done and still lower when the condition of the bowel permits the avoidance of a resection.

REPORT OF CASES

CASE 1.—Mrs. M. S., a 58 year old white rooming-house operator, was admitted to the Norwegian-American hospital at midnight on Jan. 13, 1948. Gradually increasing abdominal pains, bloating and belching, not affected by food, had started one month previously. Severe abdominal cramps, starting five days prior to her admission, were followed in twenty-four hours with persistent vomiting, which later became stercoral in character, and at the same time her bowel movements became irregular. Since the day of admission she could retain nothing taken by mouth.

She felt well until the onset of the present illness, but two years previously a uterine suspension and repair of a cystocele had been followed by weakness lasting three months. She has occasional attacks of palpitation and sleeps on two pillows.

The only noteworthy findings on physical examination were that the skin was dry and wrinkled, the tongue dry and coated and the abdomen slightly distended, rigidity was absent, tenderness was present in the lower left quadrant near the symphysis pubis, bowel sounds were absent (induced sounds were tinkling and hollow) and no masses were palpated. A midline surgical scar in the lower abdominal area was observed. Marked prolapse of the rectovaginal wall was noted. Rectal examination revealed no abnormalities.

Roentgenographic examination of the colon and several inches of the terminal portion of the ileum failed to show any obstruction. Distention of the small intestines with gas and a stepladder arrangement indicated an obstruction rather low down in the bowel. The hemoglobin, erythrocyte, leukocyte and differential leukocyte counts, prothrombin value, serum chlorides and total plasma proteins were all normal. The nonprotein nitrogen was 53 mg. per hundred cubic centimeters of serum. Urinalysis showed a specific gravity of 1.020, albumin (4 plus) and a microscopic field loaded with casts.

During the next nineteen hours, 6,500 cc. of fluids, including 500 cc. of whole blood, administered intravenously, continuous aspiration of the stomach and duodenum and intramuscular injection of 50,000 units of penicillin every three hours and 0.5 Gm. of streptomycin three times daily failed to improve her condition. The abdominal distention was marked, there was generalized tympany, bowel sounds were absent, shock was increasing, the sensorium was somewhat clouded and the patient's general condition was declining.

Accordingly an emergency operation, with the patient under ethylene, ether and oxygen anesthesia, was performed at 7 p. m. and the following observations made (fig. 3): The small intestine was tremendously dilated with gas and fluid except for the terminal portion of the ileum and the colon, which were collapsed. In the rectouterine cul-de-sac there was an acutely inflamed, adherent mass of small bowel, which, when freed and delivered into the wound, proved to be a loop of ileum which had herniated through a defect in the mesentery. The purplish gray, necrotic herniated portion had twisted, strangulated, dilated and necrosed. Both afferent and efferent loops were obstructed by the 210 degree volvulus produced by the twist. The involved mesentery was thickened and

edematous, the regional lymph glands were enlarged and the tributary blood vessels were thrombosed to the proximal arcade. There was a cordlike fibrous band attaching the strangulated bowel to the proximal mesentery. The dilated proximal and collapsed distal bowel were viable up to the point of herniation. The general peritoneal cavity contained much seropurulent fluid.

When the abdomen was opened, several feet of gas-filled small intestine extruded from the wound. It was decompressed by aspiration. The obstructed mass was freed, delivered and excised, an obstructive resection and exteriorization after the method of Mikulicz being performed (fig. 4).

Postoperative care consisted of gastric suction, administration of oxygen by nasal catheter, a parenteral fluid intake of 5,000 to 7,000 cc. daily, the use of

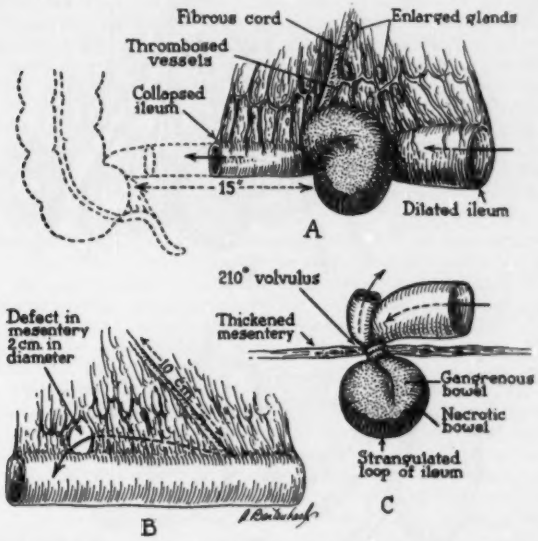

Fig. 3.—Analysis of the pathologic anatomy in case 1. *A*, the gross appearance of the strangulated, gangrenous transmesenteric hernia as it appeared at operation. *B*, appearance of bowel before herniation. *C*, cross section of herniated ileum showing volvulus in aperture resulting in gangrene and necrosis.

heparin and dicumarol® (3,3'-methylenebis [4-hydroxycoumarin]) to combat extension of the mesenteric thrombosis and crushing of the spur between the exteriorized loops of ileum. Recovery was rapid, and the patient was discharged from the hospital on January 30, sixteen days after the operation. The ileostomy opening was closed by suture two and one-half months later. She has remained in good health ever since.

Case 2.—H. P., a 51 year old white man, was admitted to a hospital on May 11, 1949, complaining of a sore throat and cough for three days, repeated and persistent vomiting, severe diarrhea and fainting for one day. He was in shock,

the blood pressure being 54 mm. of mercury systolic and 30 mm. diastolic, the pulse rate 140 per minute, the temperature 99.6 F. and the respirations 20 per minute. The past history was noncontributory.

Physical examination revealed a purulent nasal discharge, an injected, granular pharynx and roughened breath sounds, with course rhonchi in both lungs. No other positive findings were elicited in the chest, abdomen, rectum or extremities. The leukocyte count was 17,800, the erythrocyte count 5,110,000 and the hemoglobin content 16 Gm. (103 per cent). The urine had a specific gravity of 1.020 and contained albumin (2 plus), rare erythrocytes, a few leukocytes, a few hyaline and finely granular casts and mucus (2 plus). The sedimentation rate,

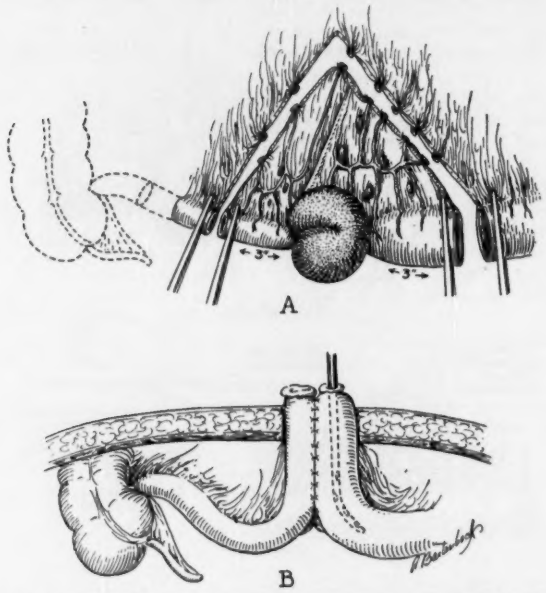

Fig. 4.—Schematic diagram of method of treatment. *A*, section of bowel to be removed. *B*, Mikulicz type of ileostomy.

electrocardiogram, roentgenogram of the chest and reaction to the Kahn tests were normal.

After entering the hospital, the patient had a chill. He vomited twice, and during the act of vomiting the second time he suddenly experienced relief and never felt ill after that time. His pulse and blood pressure rapidly returned to normal. On the third day his blood cell count was normal and his chest was normal on physical examination. He was discharged on May 15, feeling well.

On May 23, 1949, twelve days after the first attack, he experienced another attack of dull pain in the epigastrium, immediately followed by repeated vomiting. His vomiting continued until one hour after his admission to the hospital of St.

Anthony de Padua—the last few ejections consisting of a dark brown liquid—when he suddenly felt relieved and the vomiting and the sense of ill-being never recurred.

His past history was noncontributory, no previous complaints being elicited except occasional palpitation and forceful beating of the heart.

On physical examination he appeared well developed, well nourished, pale and in moderate distress. The pharynx was slightly injected, there were slight tenderness in the epigastrium and slight tenderness and rigidity in the right lower abdominal quadrant. Bowel sounds were normal. The remainder of a complete physical examination showed no significant abnormalities.

A scout roentgenogram of the abdomen and chest revealed no free air or visible masses. There was some emphysema in the lower lobes of both lungs and a moderate degree of osteoarthritis of the lumbosacral region of the spine. An electrocardiogram, excretory urogram, roentgenograms of the gastrointestinal tract and cholecystograms were normal. The sedimentation rate, blood sugar content, serum amylase and lipase levels and stools were normal, and the Kahn test elicited a negative reaction. On his admission the leukocyte count was 26,350, the erythrocyte count 4,970,000 and the hemoglobin level 15.5 Gm. The urine contained albumin (1 plus), a trace of sugar and a few leukocytes. Three hours after the sudden relief from pain and vomiting the abdominal tenderness and rigidity were gone, and from this time on the patient felt entirely well and was ambulatory. From May 24 to 28, inclusive, the respective daily leukocyte counts were 16,650, 10,490, 10,000, 9,500 and 8,800.

A provisional diagnosis of recurrent strangulation of an internal hernia was made. On May 31 an abdominal exploratory operation was performed. Examination of the entire abdomen revealed nothing abnormal except that the right internal inguinal ring contained a small empty hernial sac which barely admitted the distal phalanx of the index finger and measured 1.5 by 2.4 cm. The left lateroinferior peritoneal reflection of the sigmoid mesocolon, just proximal to the junction of the rectosigmoid with the sigmoid colon, contained an empty hernial sac that easily admitted three fingers at its orifice, and two fingers could pass into the sac to beyond the middle interphalangeal articulation. The sac was directed upward (cephalad) over and beyond the anterior surface of the sacrum and measured 4.0 cm. in diameter by 6.0 cm. deep. The liver was chocolate brown, with a lacelike network of gray fibrous tissue showing through its serosa; its smooth, sharp inferior margin extended not more than 1.0 cm. below the costal margin. The appendix showed no gross pathologic changes beyond a few paraappendical adhesions.

A right paramedian incision 22.0 cm. long was made and the abdomen opened and explored. The inguinal hernia sac was picked up at its apex, inverted and obliterated by encircling its base with two successive purse-string sutures of chromic 0 surgical gut and excising the excess portion. The intersigmoid hernial sac, being too large to invert, was obliterated by placing purse-string sutures of chromic 0 surgical gut successively from its apex to its orifice. The abdomen was closed.

The postoperative course was uneventful except for a recurrence in exaggerated form of the "hard beating" of the heart which the patient had previously complained of. He was deprived of his ambulatory privileges and given 1/100 grain (0.6 mg.) of atropine sulfate hypodermically three times daily. The irregularity of the pulse disappeared promptly. The sutures were removed on the fifth postoperative day, and he was discharged on the tenth day, since which time he has

remained well except for rare extrasystoles. Six months after operation the right indirect inguinal hernia reappeared. It was repaired three months later (February 1950).

SUMMARY

The literature is reviewed, and a case of obstructed transmesenteric hernia and one of a combined intersigmoid and indirect inguinal hernia with recurrent intestinal obstruction are reported. The various types of internal aperture or sacless hernias are illustrated. Obstructed transmesenteric hernia has been variously reported as the cause of 1 in every 101 to 218 cases of acute intestinal obstruction and of 1 in every 9 cases of intestinal obstruction due to intra-abdominal hernia. The etiology, mechanism of production and clinical features are discussed, and an analysis is made of the various types of treatment. An effort is made to clarify the early or prodromal features of internal hernia in general so that earlier diagnosis may be made and prompter definitive treatment instituted.

BENIGN AND MALIGNANT EPITHELIAL TUMORS OF THE THYROID GLAND

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MANY OF the controversial aspects of thyroid disease which agitated authors a few years ago have largely become adjusted. With the decrease in the frequency and importance of thyrotoxic goiter, the role of tumors of the thyroid gland is assuming increasing proportions. Because of the almost insuperable difficulties in the histologic differentiation between thyroid hyperplasia and neoplasia on the one hand and between benign and malignant tumors on the other, the whole subject of thyroid gland tumors is extremely confused and chaotic. A complete reevaluation of the entire subject would therefore appear to be in order.

The recent literature has stressed the surprisingly high incidence of carcinoma found in nodular goiters removed at operation. Curiously, this same incidence is not reflected in the statistics on patients dying of thyroid carcinoma nor in the numbers of thyroid cancers encountered in large series of unselected postmortem examinations. This disparity is more striking in retrospect. During the period of intense goiter endemicity in this country and elsewhere, the incidence of nodular goiter was reported to be as high as 40 to 60 or even 80 per cent among certain age groups of the adult population. If carcinoma occurred in the thyroids of these persons in anything like the percentage being currently reported, death from carcinoma of the thyroid gland should have been one of the leading medical problems of the day and could not have escaped the careful observation of the brilliant clinicians of the time.

These reflections suggest one of several possibilities. First, it may be that the accepted histopathologic criteria of malignant growths of the thyroid gland are not reliable and that many of the so-called cancers found in surgical specimens of goiter are not cancers at all. A second possibility is that cancer of the thyroid gland differs biologically from

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From the departments of surgery and pathology, Michael Reese Hospital.

cancer elsewhere in the body in that its course may be extremely prolonged and its mortality rate relatively low even with indifferent and conservative extirpation. A third explanation, recently pointed out by Crile,[1] is the fact that the nodular thyroids removed at operation occur in a selected group in which the suspicion of carcinoma is largely responsible for their coming to operation. The many obviously innocent and harmless nodules are screened out by the surgeon and are not included in the surgical pathologic material.

From a practical point of view the confused status of thyroid tumors presents two extremely serious problems in the management of nodular goiter. First, if the incidence of malignant growth or the danger of subsequent carcinomatous degeneration is as great as recent statistics would appear to indicate, the question of prophylactic extirpation of all nontoxic nodular goiters would have to be seriously considered. In the second place, if the pathologist reports the presence of carcinoma

TABLE 1.—*Type of Gland Encountered in 1,871 Surgical Specimens*

Hyperplastic thyroids		723
Nodular thyroids with hyperplasia		714
Nodular thyroids without hyperplasia		382
Carcinomas		52
Malignant adenoma	7	
Papillary adenocarcinoma	23	
Adenocarcinoma	11	
Carcinoma simplex	7	
Undifferentiated carcinoma	4	

in an excised nodular goiter, is the surgeon obligated to subject such a patient to radical dissection of the neck, with perhaps postoperative irradiation, as would be done if carcinoma of any other organ was discovered?

In an attempt to find the answer to some of these problems, we have studied the thyroid material at Michael Reese Hospital for the eighteen year period from 1930 to 1948. During this time, 1,871 surgically removed thyroid glands were received in the pathology laboratory of the hospital. All patients for whom a diagnosis of tumor of the thyroid gland, whether benign or malignant, was made were subjected to careful reexamination. In addition to a critical study of the histologic preparations the clinical charts were reviewed, and a follow-up was obtained whenever possible in all cases in which a diagnosis of carcinoma had been made or suspected.

1. Crile, G. J., Jr.: Practical Aspects of Thyroid Disease, Philadelphia, W. B. Saunders Company, 1949. Crile, G., Jr., and Dempsey, W. S.: Indications for Removal of Nontoxic Nodular Goiters, J. A. M. A. **139**:1247 (April 30) 1949.

A classification of the 1,871 thyroid specimens surgically removed during the period covered by this investigation showed that 723 were diffusely hyperplastic thyroids, 714 were nodular goiters with evidence of hyperplasia, 382 were nodular goiters without evidence of hyperplasia and 52 were carcinomas. All the malignant tumors occurred in or produced nodular enlargements of the thyroid gland. Thus 52 of the 1,148 nodular thyroids (4.5 per cent) fulfilled the histopathologic criteria for malignant tumors. Table 1 lists the type of gland and the type of carcinoma encountered in this study.

True benign tumors or adenomas were found in 102 of the 1,871 surgical specimens examined. Two types of adenomas were recognized, the papilliferous, which comprised 71 (70 per cent), and the simple, which accounted for the remaining 31 (30 per cent). Since some of these were found in diffusely enlarged thyroids and others in nodular goiters, the frequency of true benign tumors must be expressed in terms of the total number of thyroids examined. In our material, therefore, these tumors were encountered in 5.4 per cent of the specimens studied. In almost all our cases the adenoma was an incidental finding in glands removed for gross thyroid disease with or without symptoms of hyperthyroidism. Only rarely did it comprise the lesion for which thyroidectomy was performed.

The size of the adenomas was found to be as follows:

Size	Number
1 cm. or less	76
1.5 cm.	5
2 cm.	8
3 cm.	3
4 cm. or over	10

Most of them were small, and only 26 exceeded 1 cm. in diameter. The remaining 76 were 1 cm. or smaller, and many were microscopic in size.

Malignant tumors, as stated, were found in 52 of the 1,871 thyroid glands examined. It must be emphasized that in most cases the diagnosis of carcinoma was entirely unsuspected prior to operation. The operation which was performed consisted in all instances of a routine partial or subtotal thyroidectomy, for either toxic or nontoxic goiter. In a few instances only a hemithyroidectomy was performed. After the establishment of the diagnosis of carcinoma, secondary radical dissection of the neck was done in only 2 cases, in another clinic five and ten years respectively after the original operation. Postoperative irradiation was found to have been given in every case that could be followed. Table 2 indicates the number of patients followed, the number of years they were followed after the initial operation and their condition when last seen.

It will be seen that 14 (26.9 per cent) of the 52 patients were followed for five years or more and that 12 of the 14 are living and well for periods extending from five to thirteen years after the initial operation. One died of carcinoma of the thyroid eight years after operation, and 1 is living, with metastasis, six years after operation. Seventeen more of these patients were followed from one to five years, and 11 of them are living and well. Three are alive but have metastasis and 3 are dead, 1 from carcinoma of the pancreas and 2 from carcinoma of the thyroid. These last 2 lived one to four years respectively before death occurred. Death of 5 of 9 patients followed less than one year postoperatively. One of these died as a result of the operation, 1 died by suicide and 3 died of carcinoma of the thyroid. Thus, 40 of the 52

TABLE 2.—*Tabulation of Postoperative Follow-Up*

Number of Patients Followed	Years Followed	Number Living and Well	Number Living with Metastasis	Number Dead	Cause of Death
1	13	1	..	..	
1	11	1	..	..	
2	10	2*	..	..	
1	9	1	..	..	
3	8	2*	..	1	Carcinoma of the thyroid
2	7	2	..	..	
2	6	1	1	..	
2	5	2	..	..	
Total 14	5 to 13	12	1	1	
2	4	1	1	1	Carcinoma of the thyroid
3	3	1	1	..	
5	2	4	1	..	
7	1	5	..	2	Carcinoma of the pancreas; carcinoma of the thyroid
Total 17	1 to 5	11	3	3	
9	Less than 1	2	2	5	1 suicide; 1 postoperative death; 3 carcinoma of the thyroid
Total 40	1 to 13	25	6	9	

* One of these patients had a local recurrence for which radical reoperation was performed.

patients were followed. Of these, 23 (56.0 per cent) were alive and well one to thirteen years after operation, 6 were living up to six years but had metastasis and 9 had died, 6 of them from carcinoma of the thyroid. Of the 6, 3 came to autopsy and are included in our autopsy series. We were unable to obtain any information concerning the remaining 12 patients.

The period of postoperative survival according to the various types of carcinoma is shown in table 3.

Of 23 patients who were found to have papillary adenocarcinoma, 21 were followed from one to thirteen years. Of these, 17 were living and well, 12 of them from three to thirteen years; 3 had died, 1 as a result of the operation and the other 2 from carcinoma of the thyroid three and eight years respectively after operation. The results in the other types of carcinoma were much poorer. Of 6 patients with adeno-

carcinoma followed from one to three years, only 3 were living and well, 1 was living, with metastasis, and 2 had died, 1 from carcinoma of the thyroid and 1 by suicide. Of 4 patients with carcinoma simplex followed, only 1 was alive and well ten years after operation, 1 was suffering from metastatic carcinoma and 2 had died, 1 intercurrently of carcinoma of the pancreas. The undifferentiated carcinomas were most malignant, all 3 patients either dying or showing metastasis within a three month period following operation.

TABLE 3.—*Postoperative Survival According to Type of Carcinoma*

Type of Carcinoma	No. Operated on	No. Followed	Time Followed	Living and Well	Living with Metastasis	Dead	Cause of Death
Malignant adenoma	7	6	6 mo. to 5 yr.	4	1	1	Carcinoma of the thyroid
Papillary adenocarcinoma	23	21	1 to 13 yr.	17	1	3	(2 carcinoma of the thyroid) (1 postoperative death)
Adenocarcinoma	10	6	1 to 3 yr.	3	1	2	(1 suicide) (1 carcinoma of the thyroid)
Carcinoma simplex	7	4	6 mo. to 10 yr.	1	1	2	(1 carcinoma of the thyroid) (1 carcinoma of the pancreas)
Undifferentiated carcinoma	5	3	1 to 3 mo.	0	2	1	Carcinoma of the thyroid

TABLE 4.—*Survivals in Patients with Blood Vessel Invasion by Tumor Cells*

No. of Patients with Blood Vessel Invasion	Years Followed	No. Living and Well	No. Living with Metastasis	Dead	Cause of Death
1	13	1	..	..	
1	8	1	..	..	
1	7	1	..	..	
1	6	..	1	..	
1	5	1	..	..	
1	4	1	..	..	
1	3	1	..	..	
1	2	..	1	..	
2	1	1	..	1	Carcinoma of pancreas
3	6 mo.	1	..	2	Carcinoma of thyroid
2	3 mo.	..	1	1	Suicide
4	No follow-up	..	..	..	
19		8	3	4	

The cases in which a diagnosis of "malignant adenoma" was made were followed with particular interest. Of 7 patients with this disease, 6 were followed from six months to five years. Of these, 4 were living and well from one to five years after operation, 1 was living, with metastasis, two years after operation and 1 had died of carcinoma of the thyroid within six months.

The importance of blood vessel invasion by tumor cells as a prognostic index was studied. Blood vessel invasion was found in 19 of 52 cases of carcinoma. Follow-up data are available in 15 of these, as is shown in table 4.

Thus, 6 of the 15 are living and well for periods of from three to thirteen years following the thyroidectomy and 1 is alive six years after the operation but has metastasis. Eight were followed two years or less. Of these 8, 2 are living and well, 2 have metastasis and 4 have died (1 from carcinoma of the pancreas, 1 by suicide and 2 from carcinoma of the thyroid). Four could not be followed.

A further comparison of survival rates with and without blood vessel invasion in the various types of carcinoma is shown in table 5.

Thus, 5 (26 per cent) of 19 patients with blood vessel invasion survived five years or more, whereas 9 (27 per cent) of 33 without blood vessel invasion lived for a similar length of time.

Summarizing this data, it appears that the postoperative longevity is not materially lower in cases with tumor invasion of blood vessels than in those without this finding. This would indicate that blood vessel invasion is not necessarily a dire prognostic finding. The failure

TABLE 5.—*Five Year Survivals of Patients With and Without Blood Vessel Invasion by Tumor Cells*

	Number with Blood Vessel Invasion	Five Year Survival	Number Without Blood Vessel Invasion	Five Year Survival
Malignant adenoma	4	1	3	0
Papillary adenocarcinoma	5	4	18	8
Adenocarcinoma	6	0	4	0
Carcinoma simplex	3	0	4	1
Undifferentiated carcinoma	1	0	4	0
Total	19	5	33	9

of tumor thrombi to appear as remote, blood-borne metastasis shows further that there is a considerable capacity within the circulation for the destruction or containment of tumor cells. Attention is drawn to a recent study bearing on this subject by Dr. Saphir,[2] pathologist in this hospital.

During the time interval covered by this study a total of 5,558 autopsies were performed in the hospital. In this series there were only 6 cases in which death was the result of carcinoma of the thyroid gland. This gives an incidence of approximately 1 death from thyroid cancer to every 1,000 routine and nonselected autopsies. This low incidence of carcinoma of the thyroid at autopsy as contrasted with the relatively frequent occurrence of malignant tumors in surgically removed specimens is in accord with observations from other sources. During this same period, there were 2 additional deaths diagnosed clinically as carcinoma of the thyroid in which no postmortem examination was

2. Saphir, O.: The Fate of Carcinoma Emboli in the Lung, Am. J. Path. **23**:245, 1947.

performed. One of these was a surgical death two hours after operation. Thus a total of 8 deaths from thyroid carcinoma was observed in the hospital over the entire eighteen year period.

COMMENT

Definition of Terms.—In order to arrive at a basis for discussion, it is necessary that some agreement be reached regarding the meaning of the terms adenoma and carcinoma. In the earlier literature, all the nodules forming in goitrous thyroid glands were considered to be adenomas, and the terms nodular goiter and adenomatous goiter were used interchangeably. In the intervening years a great deal of evidence has been accumulated to indicate that the majority of all nodular goiters are the result of hyperplasia and that they have nothing whatever to do with true tumor formation. However, the term adenoma is still loosely used with reference to nodules in the thyroid gland, and there is no general acceptance of the exact differentiation or definition of true adenoma of the thyroid gland.

The view that the nodular masses found in goitrous thyroids are the results of the hyperplastic process and are not benign neoplasms is generally accepted today. Certain current writers continue to refer to all nodular goiters as adenomatous goiters or adenomas, with no attempt whatever to differentiate between nodules and true tumors. Others discuss true tumors apart from nodular goiter, but the distinction between the two is not clearly drawn.

Our concept of an adenoma of the thyroid is that it is a true benign epithelial neoplasm. It is made up of regular cellular elements which are arranged in clumps, cords, small abortive acini or papilliferous structures. It may or may not be delineated by a capsule but is distinguished from the surrounding thyroid tissue by an abrupt transition. Nonencapsulated adenomas are recognized in other parenchymatous organs such as liver and kidney and may, with equal logic, be expected to occur in the thyroid. This definition excludes all nodules containing colloid-filled acini and denies the existence of the so-called colloid adenoma.

We recognize only two varieties of adenomas, the simple and the papilliferous. The simple adenoma (fig. 1) includes all tumors made up of either cords of eosinophilic cells which are regular in size and shape or masses of very small acinar structures which are devoid of colloid. These are not considered separate forms because occasionally both pictures may be combined, the central portion of the tumor revealing only cords of eosinophilic cells with the small acini in the peripheral zones. The papilliferous adenoma (fig. 2) consists of cuboidal or columnar cells with clear or eosinophilic cytoplasm arranged on stalklike structures consisting of fibrous tissue with a vascular core. Not to be

confused with papilliferous adenoma are zones of degeneration in nodular thyroids with surviving pseudopapilliferous remnants of thyroid tissue.

The term "fetal adenoma" is invariably encountered in all discussions of thyroid tumors, but there is lack of agreement as to the morphology and clinical characteristics of this lesion. The use of the term fetal adenoma is in itself confusing because it derives from two separate concepts. It was first introduced by Woelfler, who believed that these tumors developed from embryonal rests persisting from the fetal period

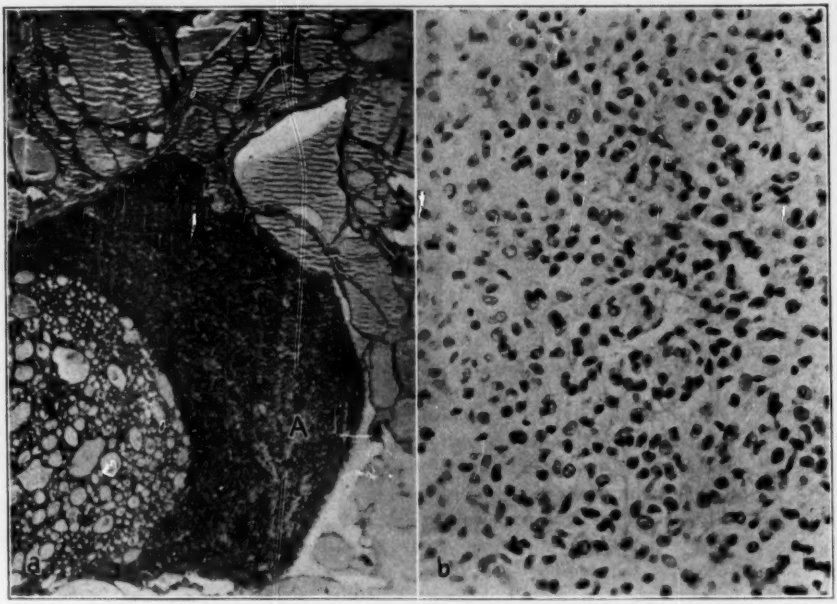

Fig. 1.—(*a*) Small simple adenoma (*A*) of the thyroid consisting of cords of clear or slightly granular cells without any tendency to gland formation. Hematoxylin and eosin stain; × 32. (*b*) Simple adenoma of the thyroid consisting of groups of eosinophilic, slightly granular cells in a well vascularized stroma. Hematoxylin and eosin stain; × 200.

of life. The existence of such fetal rests has largely been disproved. However, the term continues to be applied because of the superficial histologic resemblance of these nodules to the fetal thyroid. Because of the confusion surrounding the use of the term and its inaccuracy and because this type of tumor is merely one form of simple adenoma, we believe that use of the term fetal adenoma should be discontinued.

Adenomas of the thyroid gland may reveal histologic characteristics which in other organs are usually associated with a malignant process. Any of the previously noted varieties of adenoma may be poorly defined from adjacent non-neoplastic thyroid tissue by virtue of small finger-like cords which appear to invade. Variation in size and staining qualities of the individual cells of an adenoma which are the result of degenerative changes may also simulate malignant neoplasia. Not infrequently the resultant picture resembles Hürthle cell adenoma. Whether

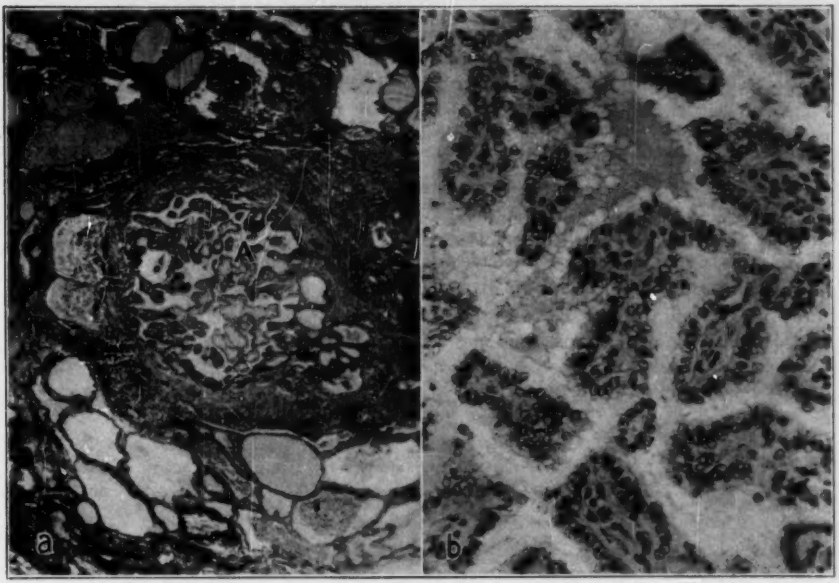

Fig. 2.—(*a*) Minute, well encapsulated, papilliferous adenoma (*A*) in nodular thyroid having foci of hypertrophy and hyperplasia. Hematoxylin and eosin stain; × 32. (*b*) Papilliferous adenoma of the thyroid, histologically benign. Note regularity of cells which are arranged on vascularized fibrous stalks. Hematoxylin and eosin stain; × 250.

Hürthle cell tumors actually exist as an entity is open to question. The presence of the large liver-like cells within some partially degenerated colloid nodules suggests that they are in all probability groups of thyroid epithelial cells undergoing varying stages of degeneration.

We have retained the term "malignant adenoma" to apply to those cases in which the pathologist is unable to make a sufficiently positive diagnosis of a malignant process in a thyroid neoplasm. These tumors

constitute, for the most part, lesions displaying some measure of proliferative activity with mitotic figures and cellular pleomorphism but not revealing blood vessel (or capsular) invasion. At the other end of the scale are the occasional instances of benign-appearing tumor which does, however, demonstrate invasion of the blood vessels. It is obvious that in this group of cases there is the greatest likelihood of error in the differentiation between adenoma and carcinoma on a histologic basis. We have classified this borderline group with the carcinomas, and they will be discussed under that heading.

In addition to the difficulties in the differentiation between benign and malignant tumors, reference has also been made to the similarities between neoplastic and hyperplastic changes in the thyroid epithelium. Those changes which constitute the usual criteria of malignant growth, such as cellular proliferation, irregularity in size, shape and staining quality of the cells and frequency of mitoses, are all seen in thyroid hyperplasias as well. This is particularly true in glands which have been subjected to thiouracil therapy. Because of the fallibility of cytologic diagnoses, Allen Graham [3] required either blood vessel invasion or capsular infiltration for the diagnosis of carcinoma of the thyroid gland. In our experience these findings are valuable adjuvants but do not represent the sole criteria of malignant growth.

With these as the bases for the diagnosis of thyroid cell carcinomas, we have divided our cases into the following classification, the characteristics on which the selection is made being discussed in the following paragraphs:

1. Malignant adenoma
2. Papilliferous adenocarcinoma
3. Adenocarcinoma (alveolar carcinoma)
4. Carcinoma simplex
5. Undifferentiated carcinoma

The malignant adenomas have been described and require no further comment. The papilliferous adenocarcinomas (fig. 3 *A*) present numerous vascularized stalks covered with a single layer or multiple layers of cells with varying degrees of pleomorphism and polychromatophilia. The adenocarcinomas (fig. 3 *B*) are less well differentiated tumors. The tumor cells tend to group themselves about clear, alveolar-like spaces. Varying degrees of atypism, pleomorphism, irregular staining reactions and mitotic activity are present. Often intermingled with these structures and comprising part of the tumor are numerous thin-walled capillaries.

3. Graham, A.: Malignant Epithelial Tumors of the Thyroid, Surg., Gynec. & Obst. **39**:781, 1924; Nodular Goiters: Their Relation to Neoplasia, Am. J. Surg. **7**:163, 1929.

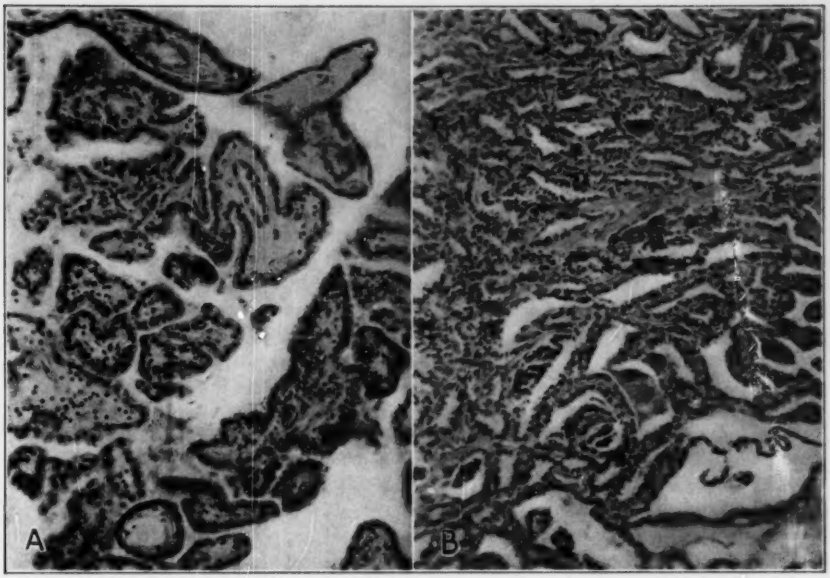

Fig. 3.—*A*, papilliferous adenocarcinoma of the thyroid. Tumor cells with greatly variable sizes and staining qualities arranged on vascularized stalks. Hematoxylin and eosin stain; × 100. *B*, adenocarcinoma of the thyroid. Irregular glandlike structures, moderately anaplastic, invading fibrous capsule of thyroid. Invasion of blood vessels was noted elsewhere.

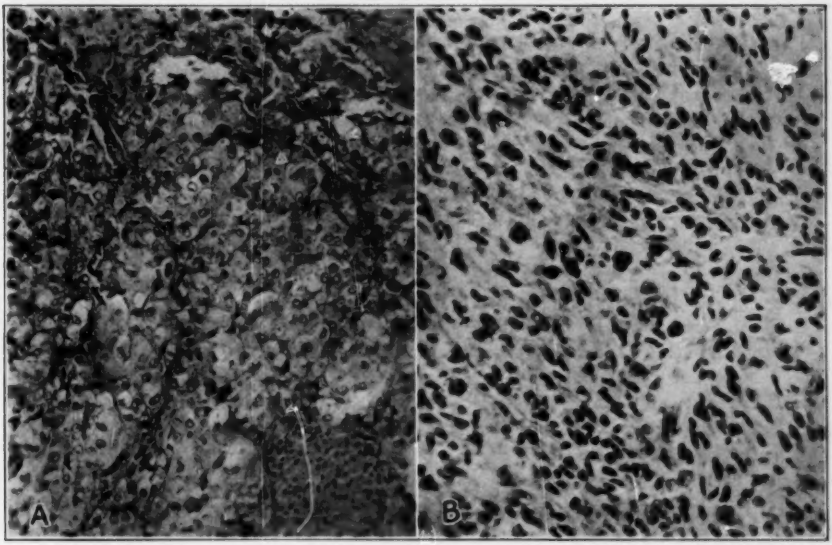

Fig. 4.—*A*, carcinoma simplex of the thyroid. Masses of undifferentiated tumor cells, the majority large and pleomorphic. No evidence of glandular or papilliferous arrangement. Hematoxylin and eosin stain; × 100. *B*, highly anaplastic undifferentiated carcinoma of the thyroid. Numerous atypical mitotic figures. Resembles so-called sarcoma of the thyroid in some respects. Hematoxylin and eosin stain; × 200.

Carcinoma simplex (fig. 4 *A*) presents infiltrating cords of pleomorphic cells with varying amounts or eosinophilic or vacuolated cytoplasm and variation in nuclear size and staining quality. Alveolar or papilliferous structures are notably lacking. From the histologic basis, this tumor is less malignant than the highly anaplastic undifferentiated carcinoma (fig. 4 *B*). This last type is made up of sheets of small or large spindle-shaped cells with pronounced pleomorphism. These have been occasionally classified as sarcomas.

The placing of a tumor in any of these groups is determined by its dominant histologic picture. Sections from various portions of a tumor may reveal three or even four different patterns within the same lesion. Next to the malignant adenomas, the large papilliferous adenomas with only slight degrees of anaplasia and pleomorphism present the greatest diagnostic difficulty. Unless blood vessel invasion can be demonstrated it is extremely difficult to state on purely histologic standards whether such tumors are benign or malignant.

BENIGN THYROID TUMORS

The study of our material reveals that true adenomas of the thyroid gland are rather infrequent lesions which are usually insignificant in size and of little clinical importance. They present no symptoms or objective signs by which they can be differentiated preoperatively from ordinary thyroid nodules, and minute ones are encountered in what are considered clinically to be diffuse thyroid enlargements. There was no evidence in any of our sections that carcinoma resulted from malignant degeneration of preexisting adenomas. Inasmuch as the preoperative diagnosis of adenoma cannot be made with any degree of certainty, the indications for surgical treatment must be drawn without regard to the presence or absence of such lesions.

MALIGNANT TUMORS

The crux of the entire problem of thyroid tumors is, of course, the incidence, prevention, diagnosis treatment and prognosis of thyroid cancer. It is generally believed that most thyroid carcinomas take their origin in preexistent nodular goiters. This is reflected in three types of evidence. First, statistics indicate that the incidence of thyroid carcinomas found in routine postmortem examinations is higher in regions where nodular goiter is prevalent than it is in nongoitrous regions and that the incidence is parallel with the severity of goiter endemicity. The second line of evidence has to do with the high incidence of preexistent goiter in patients with carcinomas of the thyroid gland.

This subject has been approached from a third and somewhat different point of view in the more recent literature. Numerous authors have

reported a surprisingly high incidence of carcinomas in nodular thyroids removed at operation. Thus Hinton and Lord [4] found it to be 7.6 per cent in a series of 184 nodular goiters. Cole, Slaughter and Rossiter [5] examined 523 successive nodular goiters removed at operation and found 38 (7.2 per cent) carcinomas. When the incidence of malignant tumors was compared with the number of nontoxic nodular goiters, the incidence of cancer rose to 17.1 per cent. In their solitary nodules, cancer was found in 24 per cent. Similarly, in a recent study from the Cleveland Clinic, Crile [1] showed that the incidence of carcinomas found in multiple nodular goiters was 3.4 per cent but that the incidence of carcinoma in solitary nodules was 24.5 per cent.

This surprisingly high incidence of carcinoma in nodular goiter is difficult to reconcile with certain other observations. It has been pointed out that nodular goiter was the prevalent type of thyroid enlargement in certain age groups in periods and regions of intense goiter endemicity. During this time the incidence of carcinoma was not correspondingly high.

A second disparity is seen in recent studies of the incidence of thyroid carcinoma in unselected series of postmortem examinations. Thus, Vander Laan [6] found that in 18,668 consecutive postmortem examinations in the Boston City Hospital over a 50 year period only 5 cases of carcinoma of the thyroid were found. Similar data have been reported from other clinics, and our own material shows the same divergence between the incidence of thyroid carcinoma in surgical specimens and that in routine postmortem examinations from the same institution.

A final disparate observation has to do with the postoperative survival rate of patients whose thyroids revealed malignant changes. It has long been recognized that such persons frequently live for many years despite conservative resections of the thyroid gland. Thus Pemberton and Lovelace,[7] reporting the material from the Mayo Clinic, showed that the survival rate following thyroidectomy, with or without irradiation, in all types of carcinoma was 77, 70 and 58 per cent after three, five and ten years respectively. Of patients with grade I malignant growths, 80.8 per cent were alive ten years after operation.

In a general way our data coincide with those from other clinics. A break-down of our survival records shows that the postoperative life

4. Hinton, J. W., and Lord, J. W., Jr.: Is Surgery Indicated in All Cases of Nodular Goiter, Toxic and Nontoxic? J. A. M. A. **129**:605 (Oct. 27) 1945.

5. Cole, W. H.; Slaughter, D. P., and Rossiter, L. J.: Potential Dangers of Nontoxic Nodular Goiter, J. A. M. A. **127**:883 (April 7) 1945.

6. Vander Laan, W. P.: The Occurrence of Carcinoma of the Thyroid Gland in Autopsy Material, New England J. Med. **237**:221, 1947.

7. Pemberton, J., and Lovelace, W. R., II.: Malignant Lesions of the Thyroid Gland, S. Clin. North America **21**:1037, 1941.

expectancy is determined essentially by the type of carcinoma present. The prognosis in the papillary type of carcinoma differs sharply from that in the other forms. The nonpapillary types show a gradation in both the histologic evidences of malignancy and also in the duration of life after operation.

Earlier in this paper we posed two questions in the management of thyroid tumors: (1) If the incidence of carcinoma in nodular goiter is as high as recent statistics indicate, should prophylactic removal of all nodular thyroid enlargements be recommended? (2) If the pathologist reports carcinoma in an excised thyroid gland, what should be the subsequent therapeutic program?

We are compelled to admit a reluctant change in our attitude toward the question of prophylactic ablation of nodular thyroids. With the retrospective picture in mind of vast proportions of the adult population harboring nodular goiter and the rarity of fatal thyroid cancers, the idea of wholesale excision of nodular thyroids was abhorrent. However, in the light of the picture as it exists today, as seen in our own material and that of other groups, the presence of carcinoma in appreciable proportions of nodular thyroids must be admitted. Nor can it be denied that a certain number of persons so afflicted die of cancer. The preoperative recognition of which nodular masses are benign and which malignant is not always possible. These facts demand serious consideration of the problem of routine removal of nontoxic nodular thyroids.

The reverse side of the picture, however, is somewhat less dire. In our series of cases, the percentage of malignant tumors was definitely lower than in some of the others cited. Furthermore, the less malignant forms of tumor, the malignant adenomas and papillary adenocarcinomas, predominated, and in those types the recurrences and deaths were few indeed. Against these facts the removal of nodular tumefactions may be less urgent.

Inasmuch as the indications for the prophylactic removal of nodular goiters is somewhat equivocal, some basis for selection should be sought. Instead of a routine approach, each individual case should be separately evaluated. All nodular goiters producing symptoms, either of thyrotoxicosis or of compression, should certainly be removed. Nodular masses which show evidence of increasing size and those of firm consistency should also be excised. Fixation of the thyroid mass to adjacent structures must raise the suspicion of a carcinomatous lesion, unless an inflammatory explanation for the infiltration is present.

The second problem, what course to follow when carcinoma is found in surgically excised thyroid glands, is perhaps less difficult to answer. Our own experience, like that of Crile and other observers, emphasizes the importance of the type of cancer in the prognosis and, therefore, in the management of malignant thyroid tumors. The papillary type of

carcinoma has been shown to be biologically far less malignant than are the other types. The postoperative longevity, even with partial or subtotal thyroidectomy, so nearly approaches that of the patient with nonmalignant disease that total lobectomy and radical dissection of the neck would not appear to be warranted. Even if local recurrences develop, reoperation is still possible, with considerable promise of success. At the time of reoperation, radical dissection of the neck should be done if local metastatic lymph node involvement is present. Postoperative irradiation may be used as an adjuvant to surgival excision, although the efficacy of radiotherapy in these slowly growing tumors is difficult to determine.

In the nonpapillary types of thyroid cancer, the situation is different. These behave as do malignant tumors of other organs and frequently pursue a relentless and rapidly fatal course. Such tumors demand total ablation of at least the involved lobe and frequently of the entire gland and, in addition, radical dissection of one or both sides of the neck. Whether the operation should be limited to one side of the neck or carried to both would depend on the proximity to or presence of tumor tissue in the second lobe. Because of the possibility of some thyroid tissue being left behind, postoperative irradiation is probably advisable.

SUMMARY AND CONCLUSIONS

1. Most of the nodular masses found in the thyroid gland are the result of the cycle of hyperplasia and involution and are not benign neoplasms. The terms adenoma and adenomatous goiter should not be applied to such nodules and should be reserved for true benign epithelial tumors of the thyroid gland.

2. Adenomas are true benign epithelial tumors. They were found in 5.4 per cent of the surgically excised thyroid glands in our series.

3. The criteria for the diagnosis of adenomas as distinguished from thyroid nodules are discussed. We do not accept as neoplasms encapsulated nodules containing adult acini.

4. In our material, solitary, discrete adenomas as the presenting complaint were extremely uncommon. There were no symptoms or findings on which a diagnosis of adenoma could have been established preoperatively. The presence or absence of true adenomas can therefore be of no value in establishing the indications for surgical intervention in thyroid enlargements.

5. We found no evidence to support the assumption that carcinomas develop on the basis of preexisting adenomas.

6. The term "fetal adenoma" is misleading and should be abandoned.

7. Carcinomas were found in 4.5 per cent of the nodular thyroids. While the incidence of carcinoma was lower than in some recently pub-

lished statistics, and despite the fact that the relatively less malignant forms were most frequently encountered, prophylactic extirpation of certain nontoxic thyroid nodules would appear to be indicated. The criteria for the selection of nodular goiters for prophylactic extirpation are enumerated.

8. In the eighteen year period covered in this study, 52 cancers were found among 1,871 surgically excised thyroid glands. During the same period, 5,558 autopsies were done in the hospital, and among these only 6 deaths were due to thyroid carcinoma.

9. The postoperative longevity bears a close relationship to the histologic type of cancer present. Blood vessel invasion proved to be a much less reliable prognostic index.

10. The papillary types of carcinoma are biologically much less malignant than are the other types. In papillary carcinomas initial radical operations are not necessary; in nonpapillary types, thyroidectomy plus radical dissection of the neck should be carried out.

Dr. Otto Saphir, pathologist at Michael Reese Hospital, aided and encouraged us in this study.

SO-CALLED LATERAL ABERRANT THYROID

Report of a Case

GAETANO DE YOANNA, M.D.
AND
RICHARD G. McMANUS, M.D.
BROOKLYN

This is a report of a case of papillary cystadenocarcinoma of the so-called lateral aberrant thyroid in which a similar neoplasm of microscopic size was found in the homolateral lobe of the thyroid. The latter neoplasm was disclosed only by total embedding of the lobe, as urged in consultation by Dr. Fred. Stewart and Dr. Frank W. Foote, of Memorial Hospital, based on the reported experience [1] in that institution.

CASE REPORT

On Jan. 7, 1949, a 45 year old white man was examined by one of us (G. De Y.). Two months previously, while shaving, he felt a lump in the lower right side of his neck. Since then it had become larger, but no pain or tenderness was present. A firm mass about 3 cm. in diameter was palpable partially at the back of the lower end of the right sternocleidomastoid muscle. It was movable and nontender. There were no other palpable lymph nodes on either side of the neck. The preoperative diagnosis was lymphoma (Hodgkin's).

On Jan. 11, 1949, he was admitted to the Long Island College Hospital. On January 12, with the patient under general anesthesia, operation was performed through a low transverse incision made over the mass. The sternocleidomastoid muscle was retracted medially, part of its lateral border was incised and the mass was brought into view. It appeared to be a blue dome cyst. It was excised intact, and from its position it was thought to be a cystic hygroma. On January 14 the patient was discharged from the hospital, with the skin sutures removed.

The pathologic diagnosis was papillary cystadenocarcinoma.

On February 4 he was readmitted to the Long Island College Hospital and right hemithyroidectomy was performed. There was a small adenoma situated in the lower pole. On February 6 the skin sutures were removed, and he was discharged from the hospital. On February 28 a roentgenogram of the thorax showed slight cardiac enlargement. There was no evidence of malignant metastasis. On March 28 a follow-up examination showed a smooth scar, no swelling and no difficulty in speech or swallowing. The patient had no complaints.

From the departments of surgery and pathology of the Long Island College Hospital.

1. Wozencraft, P.; Foote, F. W., and Frazell, E. L.: Occult Carcinomas of the Thyroid: Their Bearing on the Concept of Lateral Aberrant Thyroids, Cancer **1**:574 (Nov.) 1948.

PATHOLOGIC EXAMINATION

First Specimen.—There was an intact ovoid bluish tan cystic mass measuring 3.5 by 2.5 cm. On section, the mass was found to be bilocular, the wall varying in thickness from less than a millimeter to 3 mm. Projecting into both lumens at the junction of the dividing septum with the outer wall was a friable, gray, polypoid mass 11 mm. in diameter.

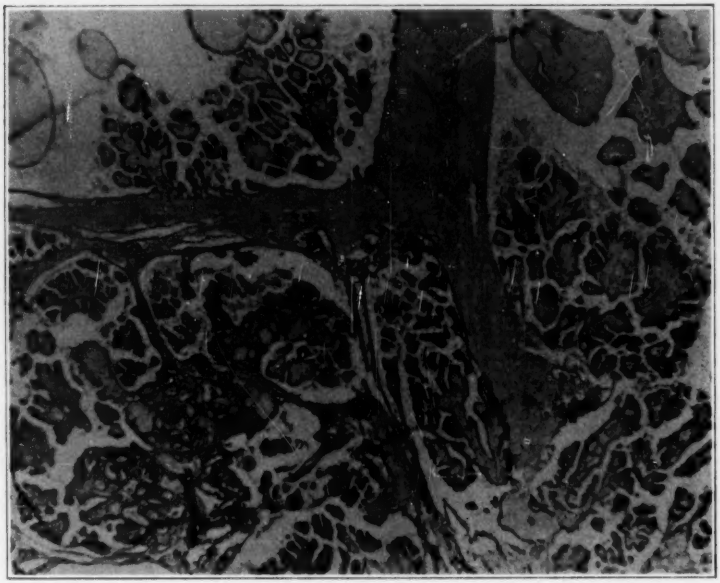

Fig. 1.—Section of wall and septum of lateral tumor, specimen 1; × 32.

Microscopically, the cyst wall and septum were both invaded—the former to a limited extent and the latter completely penetrated—by poorly formed acinar structures, lined by large irregularly cuboidal epithelium. Occasionally, these structures contained colloid-like material and resembled thyroid acini. Projecting into the lumens were papillary structures covered by similar epithelium resting on a delicate, vascular edematous stroma. The wall consisted of hyalinized fibrous connective tissue presenting moderate-sized collections of lymphoid cells and occasional foci of calcification. Although mitotic division figures were not demonstrable, the histologic picture was that of a papillary cystadenocarcinoma (figs. 1 and 2).

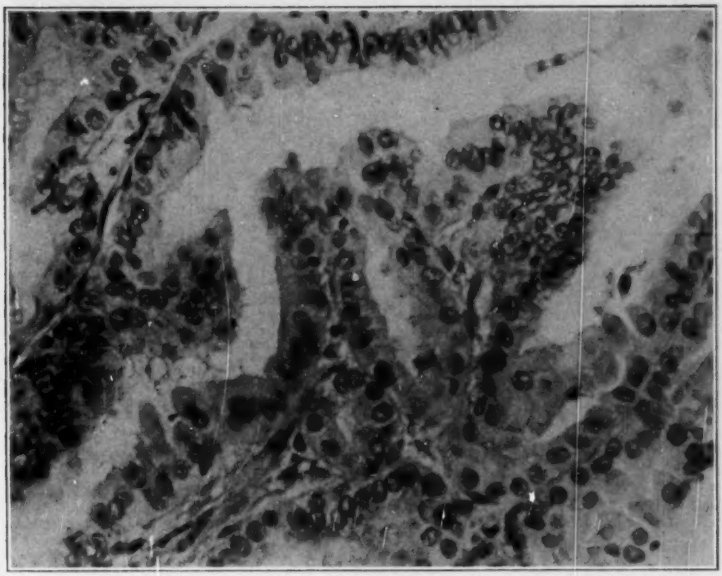

Fig. 2.—Section of wall and septum of lateral tumor, specimen 1; × 440.

Fig. 3.—Section of thyroid and tumor, specimen 2; × 32.

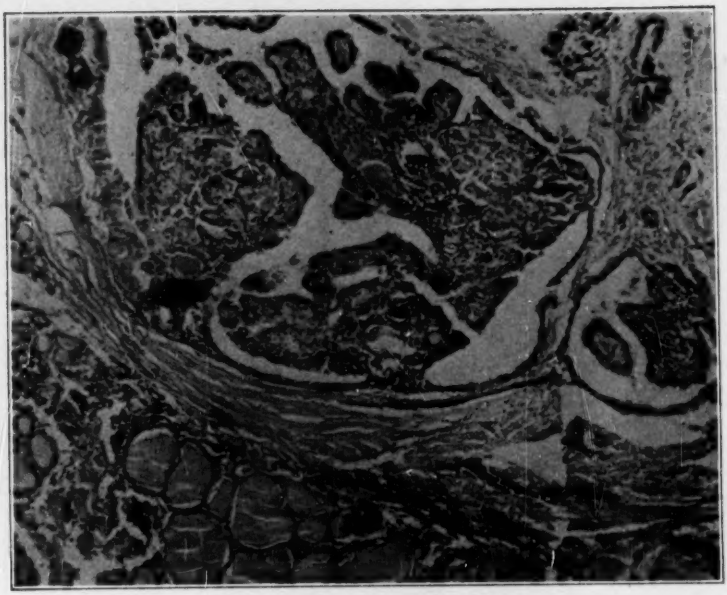

Fig. 4.—Same as figure 3; × 100.

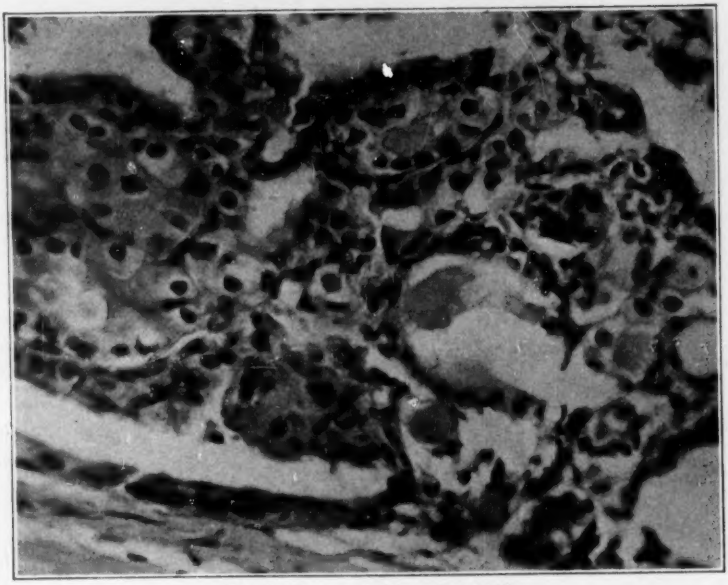

Fig. 5.—Same as in figure 3; × 440.

Second Specimen.—The resected right lobe of thyroid was not unusual externally. On section, however, located near one pole there was a thinly encapsulated, tan, firm nodule 2 cm. in diameter, slightly more opaque than the remainder of the gland.

Microscopically, this proved to be a disappointing adenoma composed of small or moderate-sized acini lined by low cuboidal epithelium. These acini contained well formed colloid and were irregularly separated by homogeneous stroma. When further random sections disclosed no tumor similar to the first specimen, the entire lobe was embedded, comprising a total of fifty-eight blocks, each no more than 2 mm. thick. Still no evidence of malignancy was found, and serial sectioning of each was started. Fortunately for the technicians, the first block brought the tumor to light. It was less than 1 mm. in greatest dimension and presented structural and cellular details similar in all respects except size to the histologic picture seen in the first specimen (figs. 3, 4 and 5).

COMMENT

The tendency to regard the "lateral aberrant thyroid" as a metastatic malignant growth from a primary tumor in the thyroid was stimulated by Pemberton.[2] Although this interpretation has been disputed by Lahey and Ficarra,[3] such a concept is becoming more widely accepted. Crile,[4] in a review of 18 cases of "lateral aberrant thyroid," reported finding a similar tumor in the thyroid in all those in which the gland was examined (16 cases). Warren and Feldman[5] presented an analysis of all the lateral thyroid tumors received in the laboratory of the New England Deaconess Hospital (57 cases). In 49 of these there was also a cancer in the thyroid, all but 1 being identical in characteristics. In the remaining 8 cases the thyroid was not received. The smallest of these "primaries," however, was 1.0 cm. in Crile's report and 0.5 cm. in that of Warren and Feldman; most were larger. The fact that these tumors may be so small as to escape notice not only on physical and operative examination but even on careful scrutiny of the excised specimen was emphasized by Wozencraft, Foote and Fra-

2. Pemberton, J., de J.: Treatment of Carcinoma of the Thyroid Gland, Ann. Surg. **100**:906 (Nov.) 1934; Malignant Lesions of the Thyroid Gland: Review of Seven Hundred and Seventy-Four Cases, Surg., Gynec. & Obst. **69**:417 (Oct.) 1939.

3. Lahey, F. H., and Ficarra, B. J.: The Lateral Aberrant Thyroid, Surg., Gynec. & Obst. **82**:705 (June) 1946.

4. Crile, G., Jr.: Papillary Carcinoma of the Thyroid and Lateral Cervical Region, the So-Called "Lateral Aberrant Thyroid," Surg., Gynec. & Obst. **85**:757 (Dec.) 1947.

5. Warren, S., and Feldman, J. D.: The Nature of Lateral "Aberrant Thyroid" Tumors, Surg., Gynec. & Obst. **88**:31 (Jan.) 1949.

zell.[1] These authors reviewed the literature for and against the anomalous origin of the "lateral aberrant thyroid" and reported 3 cases in which the tumor in the gland proper was found only by total embedding and microscopic examination, in 1 case requiring one hundred and ninety-five blocks.

SUMMARY

A case of papillary cystadenocarcinoma of the so-called lateral aberrant thyroid is reported in which thorough examination of the thyroid gland itself revealed a similar neoplasm within its substance.

CONCLUSION

This case supports the belief that in all carcinomas of the so-called lateral aberrant thyroid sufficiently thorough examination will disclose a similar neoplasm in the thyroid proper. This belief implies that the former is probably metastatic from the latter and, at least, should be treated as such.

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STAINLESS STEEL CLOTH AS AN INTERNAL PROSTHESIS

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FOR CENTURIES a problem has faced surgeons in the form of tissue reaction to the various inert substances used as ligatures and sutures. Few possibilities have been overlooked in the search for a more stable substance of either animal, plant or mineral origin which would fulfil all the surgeons' requirements. Babcock [1] has recently reviewed the background, development and present status of metallic sutures and ligatures. The high degree of tolerance for embedded stainless steel alloy wire prompted the present study of tissue reaction to stainless steel "woven wire cloth."

HISTORICAL OBSERVATIONS

The use of a metallic prosthetic material is not new. Phelps [2] in 1894 treated many inguinal hernias by approximating the layers of the abdominal wall over coiled silver wire placed on the floor of the inguinal canal. Witzel is credited by Throckmorton [3] as first suggesting to the surgical world the idea of embedding a ready-made filigree. Bartlett [4] introduced in 1903 a filigree of wire loops usually held in position by a central strand. Babcock in 1904 first attempted to close large defects in the anterior abdominal wall with fine silver wire filigree. One of the objections to silver filigree herniorrhaphy as expressed by McGavin [5] in 1907 was lack of pliability. Other factors which contributed to its obsolescence were lack of fatigability leading to fragmentation and the decomposition of the silver, which added to the adjacent tissues a permanent dark green hue. Thus the disadvantages of the metallic prosthetic material may all be attributed to the inherent qualities of the metal selected. Throckmorton has recently reported a technic for

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Abridgment of thesis submitted to the Temple University School of Medicine, in partial fulfilment of the requirements for the Degree of Master of Science in Surgery.

1. Babcock, W. W.: S. Clin. North America **27**:1435, 1947.
2. Phelps, A. M.: New York M. J. **60**:291, 1894.
3. Throckmorton, T. D.: Surgery **23**:32, 1948.
4. Bartlett, W.: Ann. Surg. **38**:47, 1903.
5. McGavin, L.: British M. J. **2**:1395, 1907.

tantalum gauze hernioplasty which gives satisfactory results. Jefferson and Daily [6] encountered no complications in their case of tantalum gauze incisural hernioplasty. Similarly, Bell,[7] Boldrey,[8] Babcock,[9] Dulin [10] and many others have testified to the lack of foreign body reactions and the high degree of tolerance by the human organism for stainless steel wire.

MATERIAL USED IN STUDY

Pieces of wire gauze were obtained from the W. S. Tyler Company, Cleveland; the National Standard Company, Niles, Mich., and the Alloy Metal Wire Co., Moore, Pa. The gauze was gaged by the number of meshes to the linear inch and ranged from no. 30, which is rather coarse, to no. 325, which in consistency and pliability is suggestive of heavy silk cloth. The no. 30 gauze may be obtained with variation in the size of wire used, ranging from 0.017 to 0.0075 inch in diameter.

Five mongrel dogs, ranging in weight from 5 to 9 Kg., were used for the study. With the use of intravenous pentobarbital sodium, anesthesia and sterile technic, at least two and in some cases three pieces of wire cloth of the size nos. 30, 78, 120, 230 and 325 were implanted in various portions of the dogs' bodies. The sites of implantation varied, as follows: (1) inner surface of the parietal peritoneum; (2) anterior surface of the great omentum; (3) as a tubular sheath for the anterior rectus muscle; (4) between the aponeuroses of the interior and internal abdominal oblique muscles; (5) between external aponeurosis and subcutaneous tissue; (6) between subcutaneous tissue and skin.

Two weeks after implantation the dogs were again anesthetized and, under sterile technic, the wire cloth was excised with the adjacent tissue en bloc. Sections were made of the tissue immediately adjacent to the wire and were examined microscopically by Dr. Ernest Aegerter, professor of pathology at the Temple University Medical School. Certain generalizations can be made concerning the findings at the second set of operations. First of all, in no case was there any gross evidence of foreign body reaction. In 3 of the animals pieces of wire cloth were placed without fixation immediately subcutaneously, underlying the line of incision. The wounds were closed with a subcuticular stitch of no. 36 wire. In each case, although the edges of the implant buckled outward and were visible, palpable and freely movable in the subcutaneous tissue, there was no inflammation, edema or infection, and in each case healing occurred per primam. It was not possible in any case to demonstrate

6. Jefferson, N. C., and Dailey, U. G.: Am. J. Surg. **75**:575, 1948.

7. Bell, R. H.: Mil. Surgeon **91**:185, 1942.

8. Boldrey, E.: Ann. Surg. **121**:821, 1945.

9. Babcock, W. W.: Ligatures and Sutures of Alloy Steel Wire, J. A. M. A. **102**:1756 (May 26) 1934.

10. Dulin, J. W.: J. Iowa M. Soc. **33**:546, 1943.

evidence of foreign body reaction clinically, nor did there seem to be any tendency for the foreign body to be extruded. Secondly, the cloth, that is, the inner surface, showed a smooth, shiny serous layer from

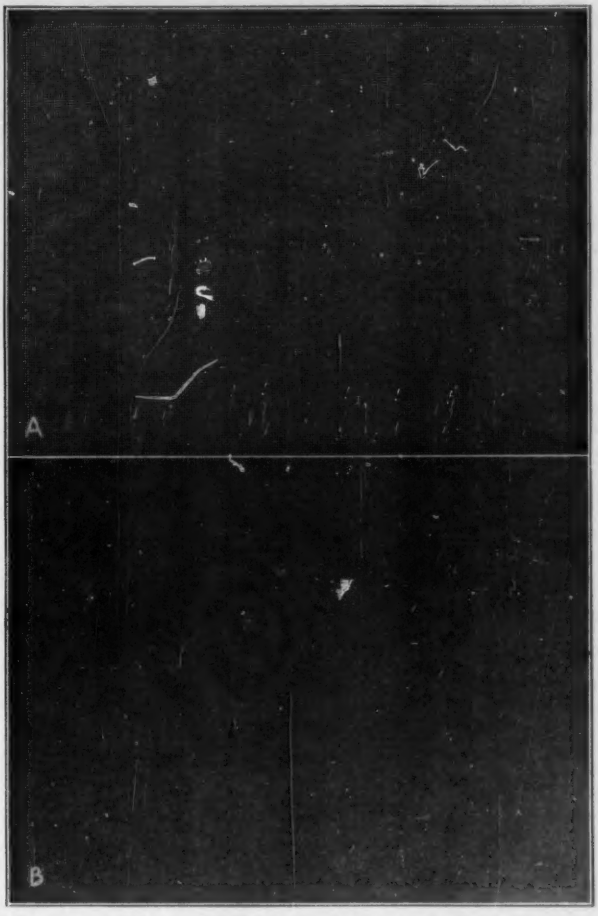

Fig. 1.—*A*, actual size no. 60 gage wire cloth; *B*, actual size no. 100 gage wire cloth.

penetration of the interstices by the peritoneum, yet without evidence of inflammation. This encasement was such that the wire cloth could

not be slipped nor its surrounding capsule removed except with a knife. There was no adherence of the implanted wire to the underlying viscera. The same was true of the wire cloth implanted in the anterior surface

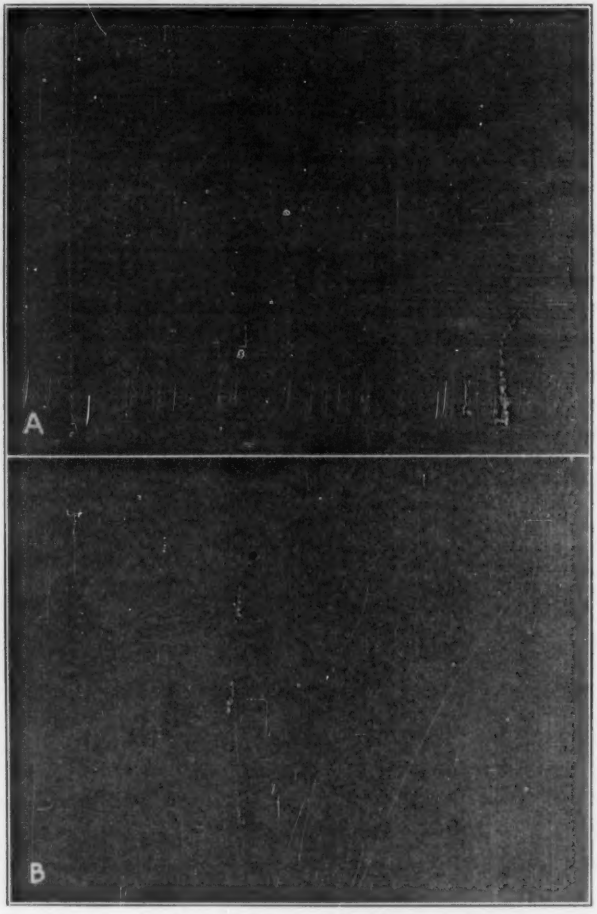

Fig. 2.—*A*, actual size no. 120 gage wire cloth; *B*, actual size no. 150 gage wire cloth.

of the great omentum. Square sections of omentum were excised and the defect closed with an implant measuring up to 3 by 4 cm., yet at

reoperation there was no adherence of this implant to the anterior abdominal wall or to loops of bowel. All the abdominal incisions were closed with no. 32 and no. 35 stainless steel wire. No wound infections were encountered.

Microscopic Study of Removed Specimens.—Dr. Aegerter, on microscopic examination of the specimens obtained as described, gave the following report: "The membranes separated from the lower mesh showed a very moderate edema and an occasional sprinkling of lymphocytes. There is some new fibroblast formation, as one would expect in a healing wound. I see no evidence of foreign body reaction." Sections were taken of the rectus muscle which had originally been mobilized and completely wrapped in the wire cloth. The microscopic report on the removed specimen was as follows: "The piece of muscle removed from inside the mesh cylinder shows almost no evidence of inflammation, degeneration or foreign body reaction. The rectus sheath which has been removed with this specimen had healed per primam and no evidence of inflammation was encountered in the sheath. In fact, when this piece of tissue was compared with a section of muscle from outside the mesh there was no essential difference."

Since this study was performed, implants of stainless steel woven wire cloth have been used in several patients on the service of Dr. W. Wayne Babcock, at whose suggestion these experiments were performed.

CASE REPORTS

CASE 1.—Mr. G. O., a 79 year old man, was admitted to Temple University Hospital on Nov. 19, 1947, for repair of an incisural hernia. His past history showed that a one stage abdominoperineal proctosigmoidectomy had been done by Dr. Babcock nine months previously for an advanced carcinoma of the rectum. At that time he had been a poor operative risk and operation had been delayed at least one year by the refusal of three other surgeons to subject him to operation. In January of 1947, when abdominoperineal proctosigmoidectomy with retention of functional anus was done, the patient's postoperative course had been complicated by the development of hiccups which proved recalcitrant to any type of therapy with the exception of carbon dioxide inhalations and which persisted intermittently for about two weeks, whereupon an incisural hernia developed. In other respects, however, his recovery had been uneventful, and he was discharged on the sixteenth postoperative day. Because of his advanced age, further operative procedures were not contemplated. At the insistence of the patient, however, repair of the incisural hernia was undertaken, as stated.

Operation.—With the patient under spinal anesthesia the old scar was excised, the sac opened and intestinal adhesions separated. The hernia was then repaired with interrupted no. 30 wire, in three layers, with imbrication of the deep layers. Because of marked attenuation of the tissues, an oval piece of no. 32 stainless steel wire cloth was implanted subcutaneously over the left inguinal canal and anchored securely at its margins with interrupted no. 32 wire to the fascia of the external abdominal oblique muscle, the rectus sheath and the conjoined tendon and inguinal ligament. Subcutaneous tissue was united over this with interrupted sutures

of no. 32 and 35 wire. The skin was closed with interrupted no. 32 and continuous no. 35 wire sutures. The patient complained of "needles" at the site of the hernia repair for about ten days. The edge of the wire cloth was easily palpable under the skin, and it was found that serous fluid was collected under the implant, requiring aspiration on two occasions, once in the hospital on the sixth postoperative day and again when he returned to the office for a check-up. The patient was discharged from the hospital on his eighth postoperative day and after the second aspiration the fluid did not reaccumulate. The local discomfort was completely relieved, and the hernial repair was satisfactory in all respects.

Comment.—In the early cases in which this method of repair of a hernia was used, it was not realized that the cut margins of the prosthetic material would produce the sticking pain of which this patient complained. Therefore, in the later cases it has been the custom to invert to about 1 cm. the margins of the entire graft so that a smooth lateral border is presented. This inversion is best accomplished with the use of a hemostat to compress the folded border.

Case 2.—Mrs. M. S., a 64 year old white woman, was admitted to Temple University Hospital on July 2, 1948, with a perineal hernia and partial obstruction of the small bowel. Her past history revealed that she had undergone perineal proctectomy in 1934 for a squamous cell carcinoma of the anal canal. Between 1934 and 1948 five attempts had been made surgically to repair a large postoperative perineal hernia, the most recent one in January 1948. She had been well until two or three weeks prior to her admission on July 2, when she began having abdominal cramps which became progressively worse. Physical examination revealed a recurrence of the perineal hernia, moderate abdominal distention and hyperperistalsis. A scout roentgenogram of the abdomen showed a partial obstruction of the small intestine, which responded satisfactorily to intubation. Then on July 8 operative repair of the hernia was again undertaken.

Operation.—With the patient in the jackknife position and under spinal anesthesia, an incision was made into the large, perineal hernial sac, which was found to be paper thin, the peritoneum lying in an immediately subcutaneous position. The peritoneum was incised around the terminal portion of the bowel and liberated to the level of the ischia. Adhesions between several loops of small bowel present in the sac were divided and the bowel replaced in the abdominal cavity. The redundant sac was carefully excised and the peritoneum closed with interrupted no. 30 wire sutures in two rows around the terminal region of the colon. A diamond-shaped portion of no. 32 wire mesh, with the edges well enfolded, measuring 10 by 12 cm. was then inserted directly over the opening into the pelvic outlet. This implant, with its long diameter running in the anteroposterior plane, was split to its center and a circular hole cut in the exact center of the gauze, measuring 3 by 3.5 cm. The terminal part of the bowel was then brought through this opening and the incision in the wire implant closed with interrupted no. 33 wire sutures. The square implant was then anchored with interrupted sutures of no. 32 wire to the tuberosity of the ischium bilaterally, to the sacrum posteriorly and to the pubic rami anteriorly. The subcutaneous tissue was closed over the implant with interrupted sutures of no. 32 wire and the skin with interrupted no. 32 and continuous no. 35 wire sutures. The patient had an uneventful convalescence and was kept in bed for eight days. The wound healed per primam; no foreign body reaction was noted at any time, and there was no collection of serum. The perineal colostomy opening was kept constipated during the immediate postoperative period, and the patient returned home on her thirteenth postoperative day. A follow-up ten months later revealed excellent bowel function. The patient does not find it necessary to

wear a pad but uses a soap and water enema to empty the bowel twice a week. The entire perineum and pelvic floor are extremely stable, and there has been no suggestion at any time of recurrence of the perineal hernia.

Comment.—In this case it was of vital importance to evert carefully any sharp ends of wire around the central opening or line of incision in the prosthetic material, since the heavy gage cloth used (no. 32) could easily have caused an intraperitoneal perforation of the terminal portion of the colon. The stability of this hernia repair is most gratifying in view of five previous attempts, all unsuccessful.

CASE 3.—Mr. H. B., a 67 year old white man, was admitted to Temple University Hospital on Sept. 23, 1947, with a complaint of right inguinal hernia of one year's duration. Hernioplasty performed the following day with the patient under spinal anesthesia revealed a Littre hernia, the mesoappendix being adherent to the sac. A cautery appendectomy was done, the mesentery being ligated in sections over the stump with no. 32 wire. The hernia sac was liberated, the neck of the sac transfixed and the sac excised. With a needle on each end of the transfixion ligature, the neck of the sac was then transplanted under the lateral border of the

Fig. 3.—Perineal hernia repair. Photograph at operation showing the terminal portion of the bowel protruding through the prosthetic material. The operation was completed by uniting the skin and subcutaneous tissue.

rectus sheath and the two ends sutured to the shelving portion of the inguinal ligament. The conjoined tendon was then united to the lacunar ligament and to the shelving portion of the inguinal ligament with interrupted no. 32 wire sutures. The aponeurotic layers were of poor quality, so a 7 by 7.5 cm. section of no. 160 wire mesh was placed over the deep row of sutures and held in place by imbricating the edges of the external abdominal oblique aponeurosis over it. The patient was ambulatory on his first postoperative day and was discharged on the seventh postoperative day. The wound healed by primary intention, with no evidence of edema, infection or foreign body reaction. Follow-up examination one year later revealed a tight external ring with no evidence of recurrence.

Comment.—Because of the fine caliber of the mesh used in this case (no. 160), the implant not only could not be palpated but was not visible on roentgenologic examination, unless the roentgenogram was taken in the posterior-anterior projection with the implant as close to the plate as possible, in which case it could be distinguished very faintly.

CASE 4.—Mr. C. S., a 69 year old white man, was admitted to Temple University Hospital on Oct. 4, 1948, with the diagnosis of metastatic carcinoma of the anterior abdominal wall and partial obstruction of the small bowel. The past history revealed that the patient had been operated on for an advanced carcinoma of the rectum in October 1946 by Dr. Babcock, at which time he had undergone abdominoperineal proctosigmoidectomy, with retention of a functional anus. The carcinoma was large and was found invading the prostate and the left lateral pelvic wall. Within one year palpable recurrence developed in the pelvis and in the abdominal scar, but the patient continued to be ambulatory and active. One month prior to his admis-

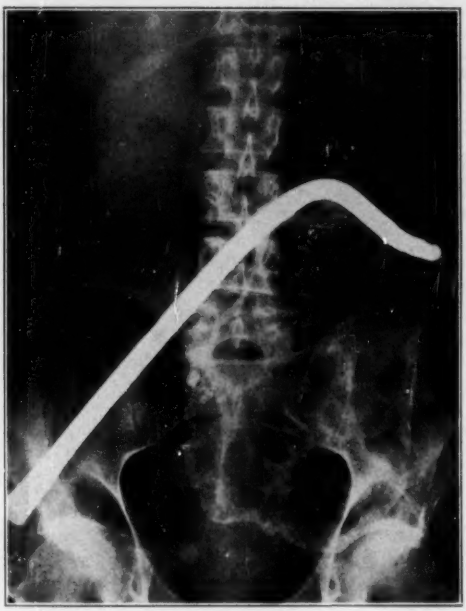

Fig. 4.—Postoperative roentgenogram, showing the prosthetic material. The rectal tube is in the colostomy opening in the left upper quadrant.

sion on October 4 he began having cramping abdominal pain which increased in severity, accompanied with abdominal distention and obstipation. On October 6, after adequate hydration, the abdomen was explored with the patient under spinal anesthesia. The metastatic tumor in the anterior abdominal wall was excised en bloc and, when liberated, was found to involve two loops of ileum and the mid-portion of the transverse colon. The adherent loops were left undisturbed and two end to end anastomoses performed, one between the ileum and cecum and one on the transverse colon. The pelvic colon was then liberated and exteriorized through the abdominal wound. The defect in the anterior abdominal wall was closed by placing a section of stainless steel wire cloth over the defect and uniting it to the

fascia at the edges with interrupted no. 32 wire sutures. The skin was then approximated over the prosthetic cloth with interrupted no. 32 and continuous no. 35 wire sutures. The patient tolerated the procedure well and remained afebrile in the postoperative period. He had no abdominal distention at any time but remained almost anuric. His blood urea nitrogen rose steadily until his death on the ninth postoperative day. The following is the pathologist's report on the autopsy, which was limited, on the request of the family, to the abdomen:

"The body is that of a white elderly man weighing 135 pounds. A colostomy opening presents itself in the left upper quadrant.

"An incision is made from xiphoid cartilage to pubis. The anterior abdominal wall with the exception of skin and subcutaneous tissue is replaced with a fine mesh wire screen. Both recti and the medial aspects of the left external and internal oblique muscles are absent. The screen is sutured firmly to fascia, and all sutures are intact. There has been no loosening, and nowhere is the fascia torn. There is almost no reaction in the tissues that are in contact with the screen. No areas of degeneration or necrosis are present. Several loops of small bowel are in direct contact with the under surface of the screen, but only one loop is adherent. The latter is easily separated by blunt dissection with the finger. There is no peritonitis or ascites.

"A recent ileocecostomy has a patent anastomosis that admits two fingers, and an end to end anastomosis of the transverse colon admits one finger. Neither of these areas shows any inflammatory reaction, and all sutures are intact. The liver shows no gross evidence of metastasis. The kidneys are removed. Each weighs about 175 Gm. They are swollen, and the capsules strip with ease. They are diffusely involved by a mottled process, areas of red and blue discoloration running together on both cortical surfaces and cut section. This has blurred the usual corticomedullary markings. There is no gross evidence of hydronephrosis, hydroureters, pyelonephritis or vascular disease.

"The cause of death is renal insufficiency secondary to 'nephron nephrosis' following operation."

Comment.—The nature of the metastatic process in this case militated against a lesser procedure. Obviously any curative operation was out of the question, but it was felt worth while to attempt to relieve the obstructive symptoms. The involvement by extension of two loops of small bowel plus the transverse colon made resection and anastomosis the only procedure which could relieve the impending obstruction. Although the patient suffered no marked drop in blood pressure and showed no transfusion reaction, oliguria and anuria developed which did not respond to treatment. It is of interest that two thirds of the abdominal wall consisted only of the prosthetic cloth and skin, yet he was out of bed during the postoperative period, with no evidence of weakness or bulging of the anterior abdominal wall. There was no fluid collection, and the wound healed nicely. Although the interval was only nine days, the absence of any intra-abdominal inflammatory reaction seems to indicate that the tolerance of the human being for this material may parallel that found in the experimental animal.

Case 5.—Mrs. Y. C., a 61 year old white woman, was admitted to Temple University Hospital on March 9, 1949, with the chief complaint of perineal hernia. The past history revealed that in April 1944 a perineal proctectomy had been performed by Dr. Babcock for a carcinoma of the anorectal junction, which proved to be an adenocarcinoma, grade 2, arising in the rectum and invading the anus. The operation at that time consisted in removal of a wide ellipse of perianal skin, the entire pelvic floor, the levator ani muscles and the coccyx. In the five years since the original operation, no signs of recurrence of her carcinoma had developed

but she had been bothered by a persistent perineal hernia. Two previous hernioplasties had been done, one in December 1945 and one in November 1947, both unsuccessful. She reentered the hospital on March 9, 1949, for another attempt to close the defective pelvic floor. On March 10 with the patient under spinal anesthesia and in the jackknife position, an incision was made into the thin hernial sac and the terminal portion of the bowel liberated. Adhesions were divided, and the loops of small bowel present in the sac were reduced into the abdomen. An oval section of no. 30 wire mesh measuring 10 by 15 cm. was then cut to fit the pelvic opening and the edges inverted. The peritoneum was closed about the terminal region of the bowel and the wire cloth implanted next to the peritoneum after a hole was made in the cloth through which the terminal portion of the colon was brought

Fig. 5.—Secondary repair following plastic reconstruction of an exstrophy of the bladder. Operative photograph shows the prosthetic material implanted over the bladder neck.

out. The edges of the wire screen were anchored to the margins of the pelvic outlet with interrupted no. 32 wire sutures. The skin and subcutaneous tissue were then closed about the bowel end. The patient made an uneventful recovery, the protruding bowel end being removed by a snare on the tenth postoperative day. She was discharged from the hospital on the fourteenth postoperative day. On reexamination in the office two weeks later, the anterior edge of the implant, which lay immediately posterior to the vagina so that it could not be securely anchored, was visible and palpable where it protruded between the skin edges for about 1 cm. The wound was well healed about it, and the patient's only complaint was that she

"scratched her fingers when bathing or cleaning herself." This edge was trimmed flush with the skin and has not caused any further trouble. The perineum is firm and stable, with no evidence of recurrence.

Comment.—The implantation of the prosthetic cloth in such a way as to allow protrusion of the edge must be considered an error in technic. However, the prompt healing of the wound about this exposed edge was most gratifying. While the follow-up period is brief, the impression is gained from examining the perineum of the patient that further herniation is extremely unlikely since the perineum is firm and unyielding. The patient is asymptomatic and is pleased with the postoperative result.

CASE 6.—C. M., a 9 year old white girl, was admitted to Temple University Hospital on March 6, 1949. This patient had been born with an exstrophy of the bladder and a prolapse of the rectum. Three operations in infancy by Dr. Harry Bacon corrected the procidentia recti, and on Oct. 12, 1942, Dr. Babcock did a first stage closure of the bladder. The second stage closure was on March 8, 1943, and further procedures were delayed until the patient was 9 years of age. On admission the child was found to have a completely closed bladder, but the bladder neck was held anteriorly by the separation of the pubic bones. She had only a slight amount of urinary control and was wet at night. Bowel function was satisfactory, and there was no evidence of recurrence of the procidentia recti. On March 7, 1949, with the patient under spinal anesthesia, the old suprapubic scar was excised and the bladder neck dissected free from the separated pubic bones. The aponeurotic layers were united between the pubic bones and reenforced by implanting a folded section of no. 120 mesh wire cloth behind the pubis and anchoring it with interrupted sutures of no. 32 wire. The skin and subcutaneous tissue were then closed over the implant with interrupted wire sutures. The patient had an uneventful convalescence and was discharged on her seventh postoperative day with a healed wound. Early postoperative follow-up is encouraging with regard to urinary continence.

POSSIBILITIES FOR THE USE OF STAINLESS STEEL WIRE CLOTH

Since the tissues of both experimental animals and human beings tolerate the continued presence of stainless steel wire cloth with no apparent resentment, my colleagues and I have speculated on the possibilities for its further application in reconstructive surgery. The condition which first comes to mind is, of course, herniation.

Dr. Dan Preston,[11] of Wilmington, Del., using this wire cloth, has successfully repaired an incisural hernia which seemed truly inoperable by normal standards. He found it necessary to anchor each lateral margin of the prosthetic material to the aponeurotic layers in the flanks, thus creating almost an entire abdominal wall of steel cloth. Postoperative examination reveals excellent support and stability.

Dr. Robert Bucher,[12] of the resident staff of Temple University Hospital, has successfully excised 1 inch (2.5 cm.) of the cervical trachea in dogs and replaced it with very fine gage wire cloth. His work will be reported in detail in the near future.

11. Preston, D. J.: Personal communication to the author.
12. Bucher, R.: Personal communication to the author.

Dr. George Rosemond,[13] of the Surgical Staff at Temple University Hospital, has successfully closed a tracheotomy opening with wire cloth after two previous closures had produced a tracheal stricture necessitating reopening of the trachea each time.

Another application which seems feasible is the incorporation in tube or pedicle grafts of an inner lining of wire cloth of varying sizes where stability at the recipient site is desired. Further experiments are contemplated to test this possibility. The nature and characteristics of an excised segment of wire cloth after two or three weeks in the dog lead us to believe that it would be easily applicable in reconstructive laryngeal surgery when the laryngeal stenosis is of such degree as to make dilation difficult if not impossible. If a coarse gage mesh, no. 60 or below, is implanted subcutaneously for two or three weeks and then excised, it will be found to have an investment of fibrous tissue which has penetrated the interstices of the wire. This layer of tissue cannot be pulled or stripped away because of its penetration of the graft. The original stability of the graft will be found increased by this fibrous investment, so that the graft has a decided tendency to maintain the shape in which it is bent by the operator. This being the case, it should be worth while in reconstructive maxillofacial and aural surgery. It is hoped that opportunities will arise to test this hypothesis further. The integrity of the thoracic cage may be restored by heavy gage wire cloth after excision of portions of the chest wall.

I have observed 1 case of diaphragmatic hernia through a large congenital defect in the left leaf of the diaphragm which, in retrospect, could have been closed with wire cloth. The patient, an infant, was operated on twenty-four hours after birth, the defect could not be closed, and the outcome was fatal.

DETAILS OF TECHNIC

No difficulty is encountered with the heavier gage mesh, 100 or below, in keeping the square foot sections flat. However, the finer gage has a marked tendency to form a roll, thus making the mesh more difficult to handle at the operating table. This can be overcome by keeping the square foot sections attached by paper clips to a square foot section of heavy cardboard until ready to use. In this way, rolling and creasing may be avoided and the tailoring of the implant at the time of operation simplified. As previously mentioned, the edges should be turned under before implantation. This has the double advantage of avoiding the sharp ends and at the same time providing a double thickness of wire cloth through which to suture. In trimming or cutting the wire cloth, old surgical scissors serve best, and, when possible, the line of division should parallel one given strand. If this is done, the crimping will

13. Rosemond, G. P.: Personal communication to the author.

prevent any unraveling. If loose strands do appear, these should be trimmed off with scissors and not pulled out. A small, sharp, cutting edge needle seems to be best suited to suturing the wire cloth. With the larger size mesh it is perfectly feasible, if wire sutures are used, to pass the sutures through the mesh without a needle, but this was found to be rather time consuming. Incisions through a wound previously reenforced with wire cloth are not particularly difficult, but the incision must extend over one free border of the implant so that the scissors blade may be inserted under the wire. Fixation of the graft in the tissues by sutures is desirable but not necessary. The penetration of the graft by fibroblasts insures its automatic immobilization. Repeated autoclaving seems to have no more deleterious effect on the wire cloth than on any instrument made of stainless steel.

ECONOMIC CONSIDERATIONS

Attention has recently been directed to the use of tantalum gauze in hernia repairs by Throckmorton [8] and others. We feel that the tantalum gauze has no superiority over that made of stainless steel and at least one decided disadvantage. A section of fifty mesh tantalum gauze measuring 6 by 12 inches (15 by 30 cm.) is listed at a hospital price of $24.40. A similar section of stainless steel mesh is readily available for $0.75, a price ratio of over 30:1.

SUMMARY

Fifteen sections of stainless steel woven wire cloth ranging in size from no. 78 to no. 325 mesh were implanted in various anatomic areas in 5 mongrel dogs. After a fourteen day interval these implants were excised en bloc. Careful clinical observations were made at the time of excision. The tissue immediately adjacent to the mesh was then sectioned and subjected to microscopic examination. Clinically and microscopically there is no appreciable foreign body reaction to this material. Fibrous tissue penetrates the interstices of the wire mesh and forms an investment for the graft. No delay in wound healing was noted. Clinical trial has been made in at least 12 cases, some of which are reported in detail, without complication and with gratifying success. Suggestions are made as to possible applications of this material in reconstructive surgery. Details of technic used in implanting the cloth are enumerated. The economic disproportion between stainless steel cloth and that made of tantalum is pointed out.

FORTISAN® (REGENERATED CELLULOSE YARN), A NEW SUTURE MATERIAL

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AND

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CHICAGO

THE USE of nonabsorbable suture material in surgery is more and more encroaching on the domain of surgical gut. Long ago Kocher [1] and Halsted [2] focused attention on the use of silk, while Meade and Ochsner [3] and Meade and Long [4] have demonstrated the superiority of cotton. More recently Whipple,[5] Shambaugh,[6] Hyde [7] and others have advocated the use of nonabsorbable sutures.

Of the various materials belonging to this group, cotton has gained the greatest popularity, its only drawback being the relatively low tensile strength. Size for size, dry surgical gut is the strongest suture material, with silk, linen and cotton following in order. Cotton, size for size, is two thirds as strong as surgical gut and three fourths as strong as silk.[3b] The tensile strength of a suitably twisted high grade egyptian cotton remains below that of true Bombyx mori silk. The "United States Pharmacopeia" allows cotton to be 40 per cent below

Dr. Warren H. Cole made valuable suggestions and allowed us the privilege of using the laboratory of the Department of Surgery, University of Illinois College of Medicine.

1. Kocher, F.: Cited by Halsted, W. S.: J. A. M. A. **60**:1119 (April) 1913.

2. Halsted, W. S.: The Employment of Fine Silk in Preference to Catgut and the Advantage of Transfixing Tissues and Vessels in Controlling Hemorrhage, J. A. M. A. **60**:1119 (April 12) 1913.

3. (*a*) Meade, W. H., and Ochsner, A.: Spool Cotton as a Suture Material, J. A. M. A. **113**:2230, 1939; (*b*) The Relative Value of Catgut, Silk, Linen and Cotton as Suture Materials, Surgery **7**:485, 1940.

4. Meade, W. H., and Long, C. H.: The Use of Cotton as a Suture Material with Particular Reference to its Clinical Application, J. A. M. A. **117**:2140 (Dec.) 1941.

5. Whipple, A. O.: Use of Silk in the Repair of Clean Wounds, Ann. Surg. **98**:662, 1933.

6. Shambaugh, P., and Dunphy, J. E.: Postoperative Wound Infections and the Use of Silk: An Experimental Study, Surgery **1**:379, 1937.

7. Hyde, T. L.: Cotton Surgical Suture Material, Surgery **16**:407, 1944.

the requirements for silk. Although the tensile strength of cotton increases to some extent after wetting, the rise is insignificant and a search for a suture material possessing all the good qualities of cotton, but markedly stronger, is considered justifiable.

Our attention has been attracted by a new textile yarn, fortisan,[8] which came into extensive use during World War II for the manufacture of fabrics of great strength. The fabrics are being used for military purposes in the canopies of parachutes, for balloon valve cords, suits and gloves for fliers and in civilian life for such varied products as raincoats, babies' garments, typewriter ribbons, life vests, umbrellas and compression bandages for the treatment of burns. Fortisan® is a regenerated cellulose yarn produced by highly orienting the internal filament structure of cellulose acetate or other cellulose ester yarn and saponifying, i. e., splitting of combined acid radicals. These operations impart to the fiber (1) great strength, (2) resistance to stretch and (3) dimensional stability under the influence of humidity or wetness.

PROPERTIES OF FORTISAN®

Strength.—Dry fortisan® has more than twice the strength of silk or cotton, and wet fortisan® is one and a half times as strong as wet cotton. Fortisan® is the strongest synthetic fiber known. The tenacity of the dry product is 7.0 Gm. per denier and that of the wet product is 6.0 Gm. per denier; a good grade silk thread shows tenacities of slightly more than 3.0 Gm. per denier, and a suitably twisted high grade egyptian cotton seldom approaches the last-mentioned figure.

The elongation of fortisan® is 8.5 per cent when dry and 8.8 per cent when wet. Its specific gravity by xylene immersion at $\left[\frac{25}{4}\right]$ is 1.5.

Resistance to Stretch.—High resistance of fortisan® to stretch avoids the puckering of the sewn seam. Such undesirable effect is observed when yarns are used that stretch readily and have a high elastic recovery: the tension created during the suturing results in a residual energy, which in turn causes puckering.

Dimensional Stability.—Fortisan® has the peculiar property of retaining its longitudinal dimension throughout wetting and drying so that expansion or shrinkage under extreme wetting or drying conditions changes the length of the yarn less than 0.1 per cent.

Autoclaving under 25 pounds (11.3 Kg.) pressure for as long as five hours does not significantly alter the physical or chemical properties of fortisan,® which is highly resistant to mildew and fungi molds.

8. The yarn is manufactured by the Celanese Corporation of America, 180 Madison Ave., New York 16, N. Y. The thread was generously supplied by Belding Corticelli, Research Division, Putnam, Conn., and the Perfect Thread Co., Inc., Empire State Building, New York 1, N. Y.

Frictional Property.—In regard to the frictional coefficient, an important factor for knot holding, there is no substantial difference between fortisan,® silk and polished cotton threads, according to the statement of the manufacturer of fortisan.®

The surface of a fortisan® thread, other than the geometric configurations of the fibers themselves, may be considered to be smooth and without protruding filaments.

DESCRIPTION OF THE EXPERIMENTS

To study the value of fortisan® in surgery, the experiments were divided into four groups:

1. Bacteriologic study.
2. Determination of the tensile strength of (*a*) autoclaved fortisan,® cotton, silk and also of plain surgical gut and (*b*) the same suture materials after implantation in rabbits' tissues various times.
3. Study of tissue reaction and wound healing in rabbits, comparing the effect of fortisan,® silk, cotton and plain surgical gut.
4. Clinical application.

Cultures of fortisan® were made in Brewer's fluid thioglycollate medium after the suture material was autoclaved for twenty minutes at 15 pounds (6.8 Kg.) pressure.

The tensile strength was determined by either a pendulum type Dillon Multi-tester or a Scott incline plane tester, recommended by the "United States Pharmacopeia." Such apparatus apply stress to the specimen at a constant rate of loading and autographically plot the characteristics of the thread tested. Preliminary experiments showed that both types of testers furnished approximately the same results, while an electrohydraulic tester proved less suitable for this purpose. Data obtained with a method consisting of simply adding weights to a suspended sample at regular time intervals are not as reliable as those obtained with either one of the aforementioned devices.

Wet test data were obtained by testing samples immersed in distilled water for five minutes at 70 F. prior to the test. The surface moisture was removed by passing the samples gently between the thumb and the forefinger.

Link strength was measured by interlinking two threads and attaching both ends of each loop to the opposite jaws of the tester. This test is preferred by the American Society for Testing Materials to testing knotted samples because it furnishes more consistent results.

The rate of separation of jaws by which the thread was held was 12 inches (30.48 cm.) per minute. The specimens were held in roller wedge type jaws to eliminate any cutting of samples. The tests were performed at a temperature of 75.5 F. and an atmospheric relative

humidity of 67 per cent, as determined with a sling psychrometer. Equilibrium with these factors was obtained by allowing the samples to remain in this atmosphere for a minimum of four hours before testing.

Under aseptic conditions four individual pockets were dissected out beneath the fascia of abdominal muscles of 12 anesthetized rabbits. A strand of boilable surgical gut 0000, surgical cotton 0000, black silk 0000 or fortisan,® size A, respectively, all of approximately equal caliber by micrometric measurements, was placed into the pockets of each rabbit as far away one from the other as was possible. The animals were killed after two, three, four, eight or fourteen days respectively, all samples were removed from the abdominal wall and several tests for tensile strength were performed on each suture material.

To study the tissue reaction and wound healing, incisions 1 cm. long were made under sterile precautions through the abdominal muscles and fascia in 12 rabbits and were closed with continuous sutures of the aforementioned materials. To eliminate individual variations in the response of tissues to foreign bodies, all four suture materials were implanted in each rabbit, as far away one from the other as was possible. The animals were killed two, three, four, eight or fourteen days respectively after the operation, the suture materials were dissected together with the surrounding tissues, placed in 10 per cent formaldehyde, embedded in paraffin, cut and stained with hematoxylin and eosin.

After the experimentations were completed, fortisan® was used in the closing of wounds in human patients. The wounds were inspected daily for signs of allergy or infection, and the hospitalization period was compared with that of patients with similar conditions in whom other suture materials had been used. The patients had a final check-up two months after the operation.

RESULTS OF THE EXPERIMENTS

Three cultures of autoclaved fortisan® on Brewer's fluid thioglycollate medium failed to reveal the presence of aerobic or anerobic micro-organisms.

The tensile strength of sizes A, B, C, D and E fortisan,® sizes 0000, 000 and 00 cotton, silk and surgical gut was determined on a Scott incline plane tester and recorded in table 1. The superiority of fortisan® can be demonstrated by comparing, for example, the tensile strength of this material, size D, with the corresponding size of cotton and silk, viz., fortisan® 8.25 to 12.20 pounds (3.7 to 5.5 Kg.), cotton 2.05 to 2.07 pounds (0.925 to 0.935 Kg.) and silk 2.00 to 3.00 pounds (0.9 to 1.3 Kg.).

Mr. Edgar J. Pagé, Research Chemist, Belding Corticelli Company, furnished table 2, which compares size A fortisan® with sizes 20, 40 and 60 commercial cotton as to tensile strength on straight pull, both dry

TABLE 1.—*Comparison of Tensile Strength of Fortisan® and Other Commonly Used Materials on Straight Pull*

Fortisan *			Cotton			Silk			Surgical Gut, Bollable			
Size	Diameter, Inches	Tensile Strength, Lb.	Size	Diameter, Inches	Tensile Strength, Lb.	Size	Diameter, Inches	Tensile Strength, Lb.	Size	Diameter, Inches	Tensile Strength, Lb.	Comment
A	0.0048	4.20	0000	0.0060	2.05	0000	0.0060	2.00	0000	0.0060	2.00	Note that size E fortisan * has approximately the same diameter as the largest strand of 4/0 or the smallest strand of 3/0 cotton or silk while its tensile strength is four to six times as great
	to	to		to	to		to	to		to	to	
	0.0065	4.37		0.0080	2.07		0.0080	3.00		0.0080	2.20	
B	0.0065	5.50	000	0.0080	3.00	000	0.0080	3.00	000	0.0080	3.00	
	to	to		to	to		to	to		to	to	
	0.0072	5.85		0.0100	4.30		0.0100	4.50		0.0100	4.00	
C	0.0068	7.25	00	0.0100	4.50	00	0.0100	5.00	00	0.0100	5.00	
	to	to		to	to		to	to		to	to	
	0.0080	9.20		0.0130	5.00		0.0130	7.20		0.0130	6.00	
D	0.0078	8.25	....	.....	....	....	.....	....	....	.....	....	
	to	to		...	...		...	...		...	...	
	0.0085	12.20		.....	....		.....	....		.....	....	
E	0.0083	12.00	....	.....	....	....	.....	....	....	.....	....	
	to	to		...	...		...	...		...	...	
	0.0100	13.80		.....	....		.....	....		.....	....	

* Registered trademark.

and wet, and also link strength, both dry and wet. A Scott incline plane tester was employed for this purpose. In spite of the fact that cotton gains somewhat in tensile strength after wetting, the table shows that it remains weaker than the corresponding size of wet fortisan.* For instance, the tensile strength of size 60 cotton was found to be 2.45 pounds (1.25 Kg.) while that of size A fortisan* was 3.40 pounds (1.5 Kg.). The tensile strength of wet linked cotton also remained below that of a similar size fortisan.*

TABLE 2.—*Comparison of Tensile Strength of Size A Fortisan* and Sizes 60, 40 and 20 Cotton*

Material	Size	Diameter, Inches	Tensile Strength, Dry, Lb.	Tensile Strength, Wet, Lb.	Link Strength, Dry, Lb.	Link Strength, Wet, Lb.
Fortisan *	A	0.0048	4.57	3.40	4.50	3.85
Cotton	60	0.0046	2.05	2.15	3.65	3.30
Cotton	40	0.0071	2.50	2.60	4.25	3.90
Cotton	20	0.0113	4.50	4.65	7.65	6.75

* Registered trademark.

The results of the determination of the tensile strength of fortisan,* cotton, silk and surgical gut after implantation in rabbits, determined with the Dillon Multi-tester, are recorded in table 3. Fortisan* retained its superiority over other materials after remaining in the abdominal wall of rabbits for various periods ranging from two to fourteen days.

TABLE 3.—*Tensile Strength of Suture Materials in Pounds after Implantation in Rabbits for a Period of Several Days*

Material	2 Days	3 Days	4 Days	8 Days	14 Days *	Comment
Fortisan,† size A	3.30	1.90	2.15	2.60	1.05	Note that during the first 8 days fortisan † A, corresponding in size to cotton 60, retains its superiority in regard to its tensile strength
Fortisan,† size B	....	....	3.05	....	1.85	
Cotton, size 60	1.60	1.55	1.65	1.45	1.00	
Cotton, size 0000	1.85	1.80	1.80	1.95	1.90	
Silk, size 0000	1.05	....	0.80	....	1.20	
Boilable surgical gut, size 0000	1.15	0.90	....	....	....	

* Not detectable at the site of implantation.
† Registered trademark.

A microscopic study was made of specimens removed two, three, four, eight or fourteen days respectively after implantation of surgical gut, silk, cotton and fortisan* into the abdominal wall of rabbits.

Figures 1, 2, 3 and 4 reproduce photomicrographs of specimens removed fourteen days after implantation of the aforementioned suture materials. There was a diffuse reaction over a considerable area around surgical gut, the infiltration consisting of polymorphonuclear neutro-

Fig. 1.—Photomicrograph of specimen removed fourteen days after implantation of fortisan.®

Fig. 2.—Photomicrograph of specimen removed fourteen days after implantation of cotton.

Fig. 3.—Photomicrograph of specimen removed fourteen days after implantation of silk.

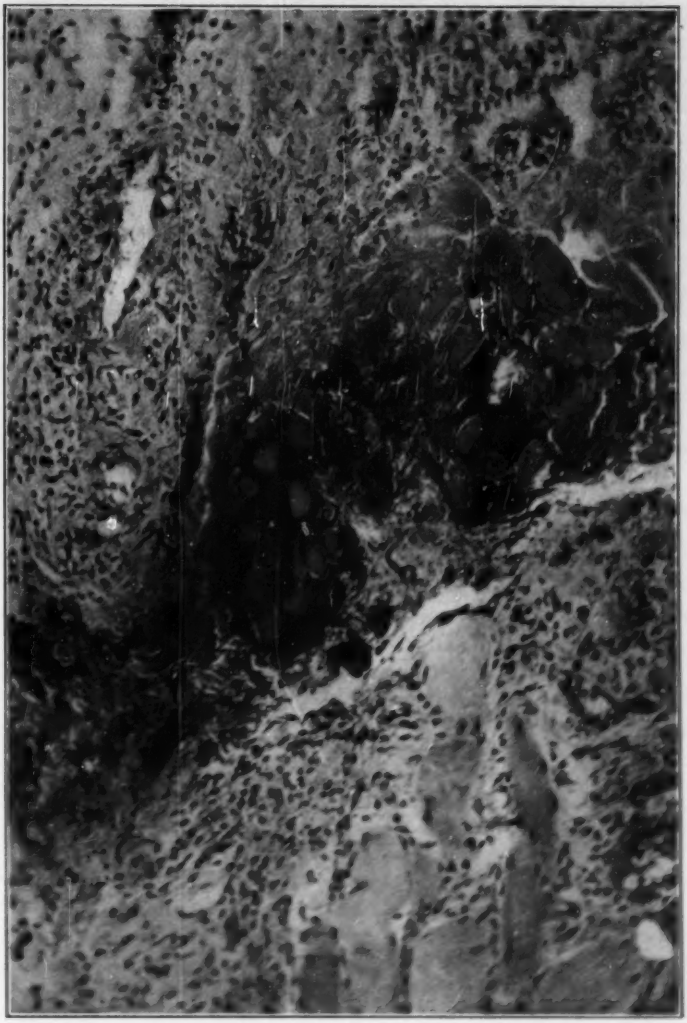


Fig. 4.—Photomicrograph of specimen removed fourteen days after implantation of surgical gut.

phil leukocytes, monocytes and eosinophils, in descending order of the number of cells. There were also a few lymphocytes and fibroblasts. The fibroblastic proliferation around cotton was pronounced, and there were numerous giant cells, not visible in specimens removed earlier than fourteen days after implantation of the suture material. The reaction was more circumscribed than that provoked by surgical gut. The tissue reaction to silk was more confined to the immediate vicinity of the suture than was the case with surgical gut or cotton. No giant cells or phagocytes could be detected. There was a mild fibroblastic reaction around fortisan® and the areas of adjacent tissue showed a slight reaction of inflammatory character.

From the study of specimens removed at various times after implantation the impression was gained that fortisan® was producing less tissue reaction than silk or cotton, although the quantitative differences were not pronounced, while surgical gut was decidedly the worst offender.

To test the value of fortisan® in general surgery, it was used at St. Elizabeth Hospital as the only suture material in sixteen operations for the following conditions: nonresectable cancer of the stomach (posterior gastroenterostomy), mechanical ileus (severing of adhesions), acute appendicitis (3 cases), gangrenous appendicitis with a periappendical abscess, cholelithiasis (cholecystostomy), umbilical hernia, inguinal hernia, ectopic pregnancy, hypospadias, undescended testicle, varicose veins, cholelithiasis (two cholecystectomies) and cancer of the pancreas (exploration).

During the postoperative period the wounds were inspected daily and showed no evidence of untoward effect of the suture material. The clinical course did not differ in any respect from that in similar cases in which other suture materials were used. Two months after the operation there was not a single sinus formation or extrusion of a suture.

COMMENT

Fortisan,® the strongest synthetic fiber known, was shown to withstand repeated autoclaving without impairment of its efficiency, to possess a tensile strength considerably superior to cotton of equal caliber and to create a minimal tissue reaction in the animal or human body.

While a discussion of the relative values of absorbable and nonabsorbable material is beyond the scope of this paper, it may be pointed out that wound healing in the presence of surgical gut is definitely retarded, as has been shown by Kocher,[1] Halsted,[2] Whipple,[3] Shambaugh[4] and others. This deterrent effect is attributable to an excessive fluid and cellular exudation and a concomitant delay in the appearance

Huhne [9] has pointed out that when surgical gut swells, it shortens, and when shortened it may break or untie the knot. Fortisan,® on the other hand, has the property of retaining its longitudinal dimension when wet. This dimensional stability contributes to the security of knots. According to the statements by manufacturers of suture materials, some brands of cotton yield slightly higher figures than those obtained by the authors, and others yield lower figures, but actually such data are not comparable unless the mode of testing and other factors, such as relative humidity and atmospheric temperature, are identical.

The tensile strength of 0000 silk, as standardized in "United States Pharmacopeia" XIII, is 2.00 pounds (0.9 Kg.) on straight pull, that of 0000 cotton is also 2.00 pounds (0.9 Kg.) while that of corresponding size fortisan® is 4.57 pounds (2.1 Kg.).

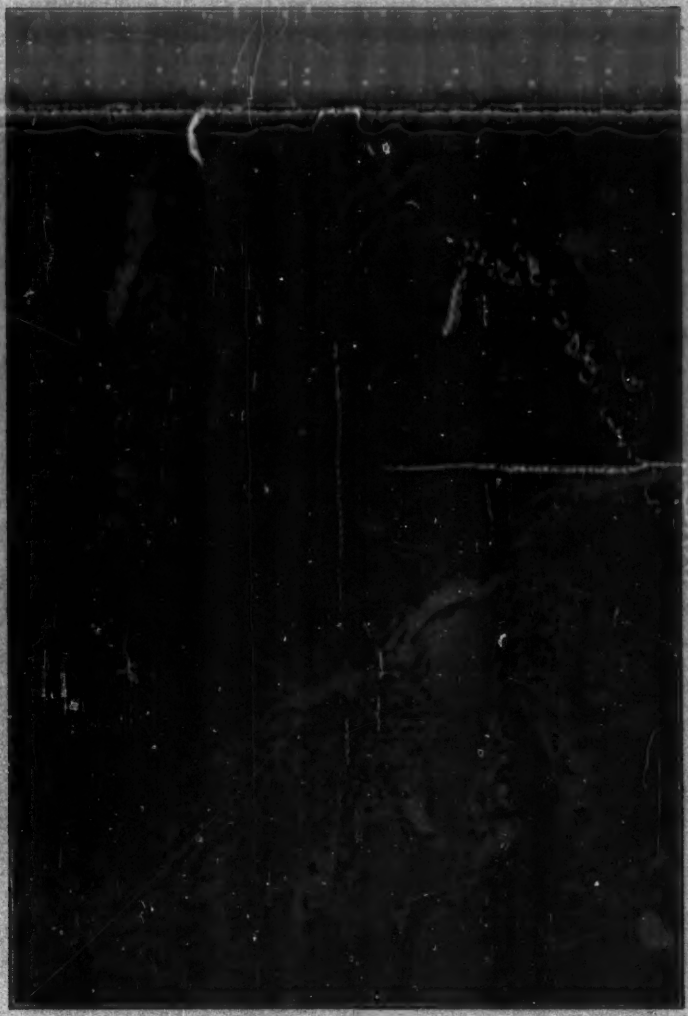
Although cotton has the unique property of gaining tensile strength slightly after wetting, the rise is not sufficient to make it as strong as fortisan.® The tensile strength of wet cotton, size 60, is 2.15 pounds (0.97 Kg.), while that of wet fortisan,® size A, which has a smaller diameter, is 3.40 pounds (1.5 Kg.). Throughout the period of implantation in rabbits fortisan® remained stronger than cotton, silk or surgical gut. In the limited number of our experiments there was a considerable loss of tensile strength of fortisan® after implantation, while cotton and silk apparently did not share this property, with the exception of size 60 cotton after fourteen days (table 3). However, Meade and Ochsner [10] found, in a larger number of experiments, that silk was losing 20 per cent of its tensile strength after fourteen days, 50 per cent after seven days and 41 per cent after ten days. In other words, the undesirable characteristics of fortisan® to lose some of its tensile strength after implantation is shared, probably to a less degree, also by silk. On the other hand, this drawback of fortisan® is well compensated by its much greater original tensile strength. For instance, after the most crucial first eight days the tensile strength of fortisan® was 2.00 while that of the comparable size of cotton 60 was only 1.45 (table 3).

Observations on a limited number of patients, in whom fortisan® was used in the repair of operative wounds, failed to reveal any excessive induration of the margins of the skin wound, extrusion of the sutures, formation of sinuses, retardation of the healing process or prolongation of the period of hospitalization. Allergy was not observed after the use of fortisan® in man or animals.

The material is pliable and uniform in size. It can be used in combination with surgical gut or wire. A tendency of dry fortisan® to fray

9. Huhne, T.: New Ways in Chromic Internal Catgut, Arch. f. klin. Chir. 161

Fig. 3.—Photomicrograph of specimen removed fourteen days after implantation of silk.



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9. Huhne, T.: Neue Wege zu einem besseren Catgut, Arch. f. klin. Chir. 166:131, 1931.

out is not apparent when the material is damp. Therefore, the natural moisture of tissues prevents the dangerous effect of fraying on the security of the knots.

As a double square knot has a tendency (shared also by cotton and silk) to slip, it is essential to tie a triple throw knot. One who has been trained in the use of surgical gut, especially sizes heavier than 0, will find some difficulty in becoming accustomed to nonabsorbable material such as fortisan.* Only such force should be used while tying a knot as is required to approximate the walls of a blood vessel and not to crush them and to obtain a coaptation of cut tissues without undue tension. Double strands should not be used. The observance of a meticulous technic is just as imperative with fortisan* as with other nonabsorbable material. The tissues should be handled with great gentleness, no heavy forceps should be applied to them and only bleeding points, with as little surrounding tissues as possible, should be caught in hemostats. Although the rationale of the rule that no continuous sutures should be used with nonabsorbable material is not convincing to us, this principle should be observed until further experience with continuous sutures is gained.

The following sizes of fortisan* thread are recommended: A (the smallest diameter of all) or preferably B for ligation of small blood vessels; C or D for closure of the peritoneum; D or E for suturing the fascia; B, C or D for skin closure, the selection depending on the amount of tension, and E for retention sutures or ligation of large blood vessels.

SUMMARY

A new nonabsorbable suture material, fortisan,* is recommended because the results of experiments on animals and human patients show that it is pliable, uniform in size, can be repeatedly autoclaved, is noncapillary, causes a minimal tissue reaction and offers the additional great advantage of possessing considerably greater tensile strength than silk or cotton.

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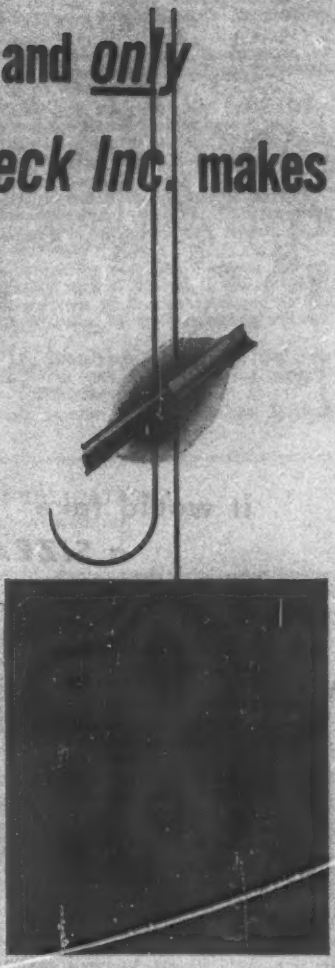

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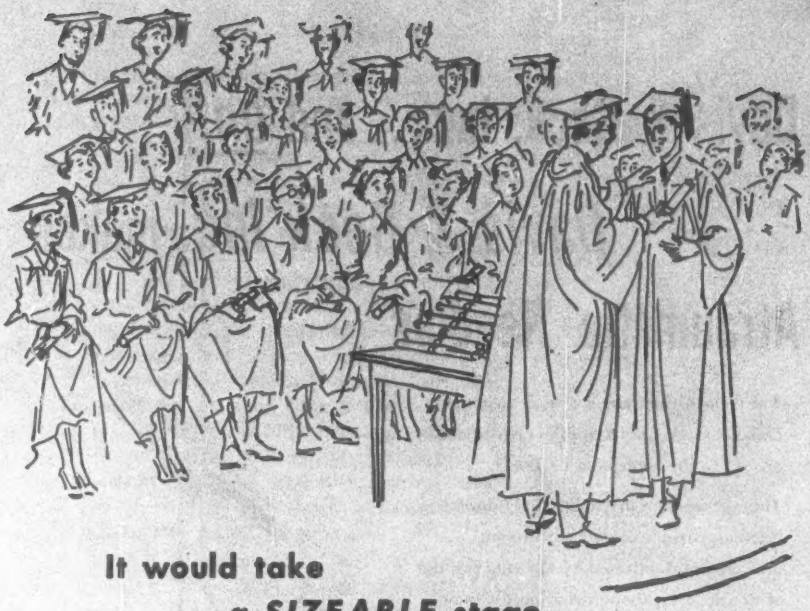

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